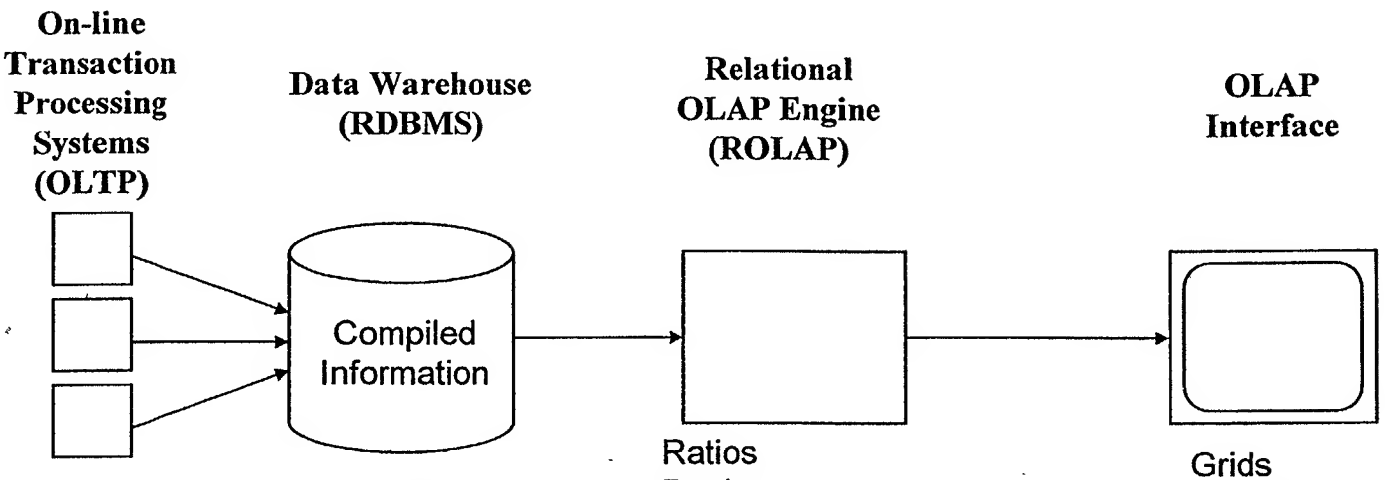


Parallel Data Query
Backup & recovery
Parallel Loading
Parallel Indexing
Hashing
Data partitioning

Ratios
Ranks
Transforms
Dynamic Consolidation
Complex Filtering
Forecasts
Query Governing
Scheduling
Flow Control
Pre-Aggregate Inferencing
Denormalization support
Table Partitioning and Joins

Grids
Graphs
Maps
Alerts
Drill-down
Data Pivot
Data Surf
Slice&Dice
Print

Database Layer

Application Logic Layer

Presentation Layer

Fig.1A
(PRIOR ART)

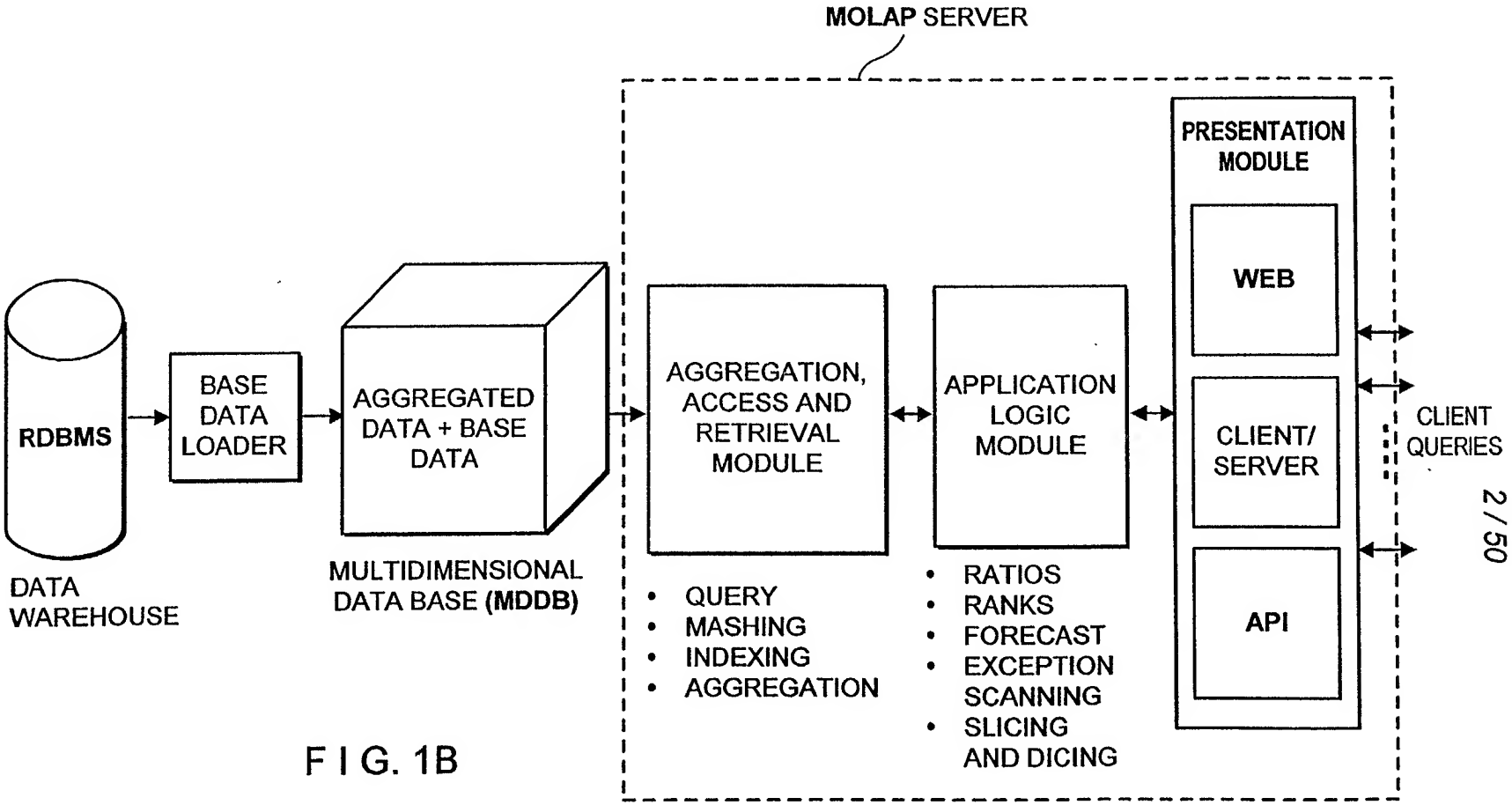

MOLAP SERVER
RDBMS
DATA WAREHOUSE
BASE DATA LOADER
AGGREGATED DATA + BASE DATA
MULTIDIMENSIONAL DATA BASE (MDDB)
AGGREGATION, ACCESS AND RETRIEVAL MODULE
• QUERY
• MASHING
• INDEXING
• AGGREGATION
APPLICATION LOGIC MODULE
• RATIOS
• RANKS
• FORECAST
• EXCEPTION SCANNING
• SLICING AND DICING
PRESENTATION MODULE
WEB
CLIENT/ SERVER
API
CLIENT QUERIES

FIG. 1B

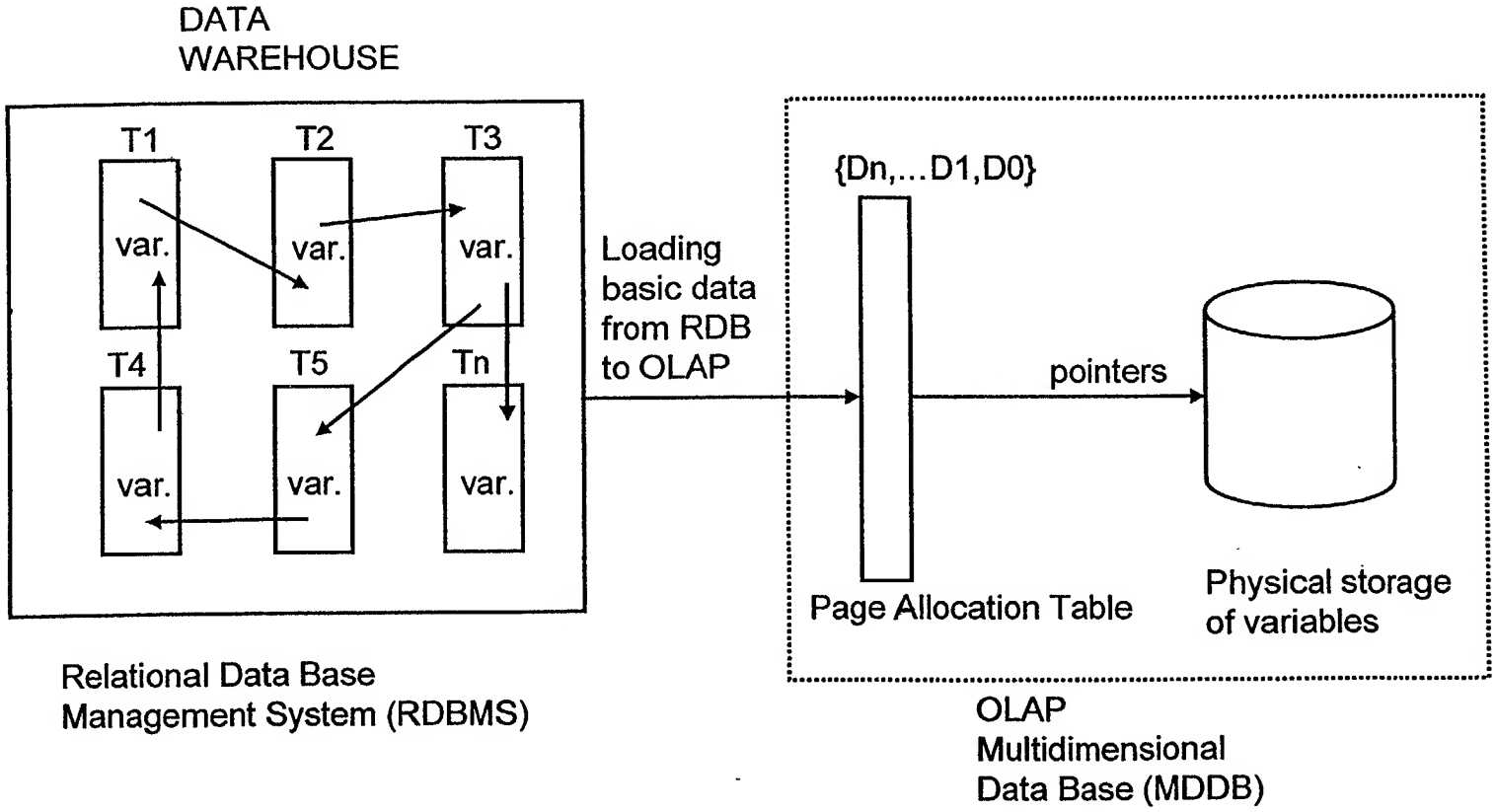
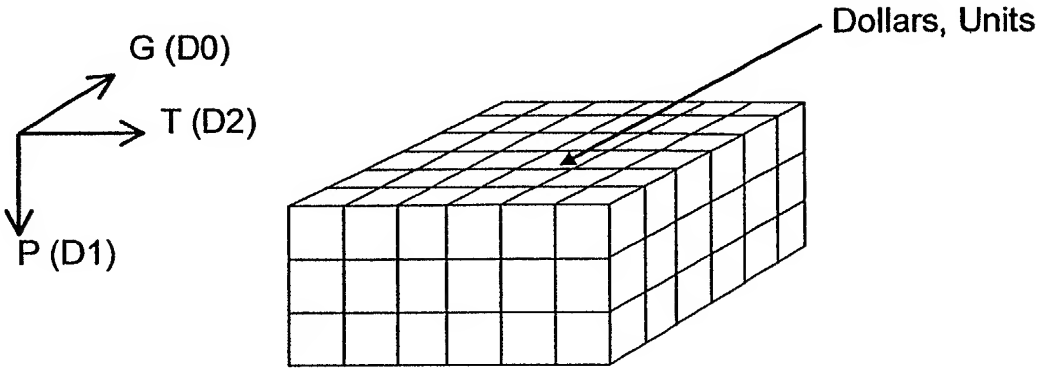


Fig. 2A
(PRIOR ART)



G	geography (e.g. cities, states, countries, continents)
T	time (e.g., days, weeks, months, years)
P	products (e.g. all products, by manufacturer)

Fig. 2B
(PRIOR ART)

Array structure of a multidimensional variable

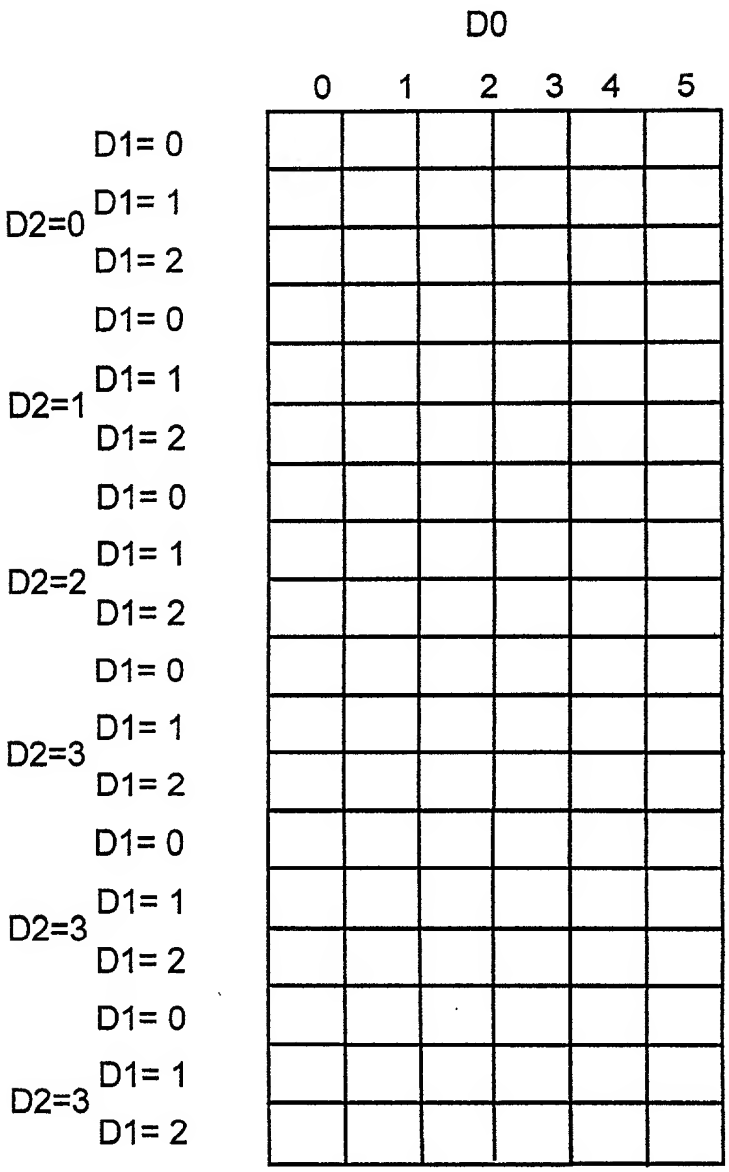


Fig. 2C
(PRIOR ART)

Page Allocation Table pointing on physical records of a multidimensional variable (e.g. the two first rows of a variable of FIG. 2B reside in page # 0)

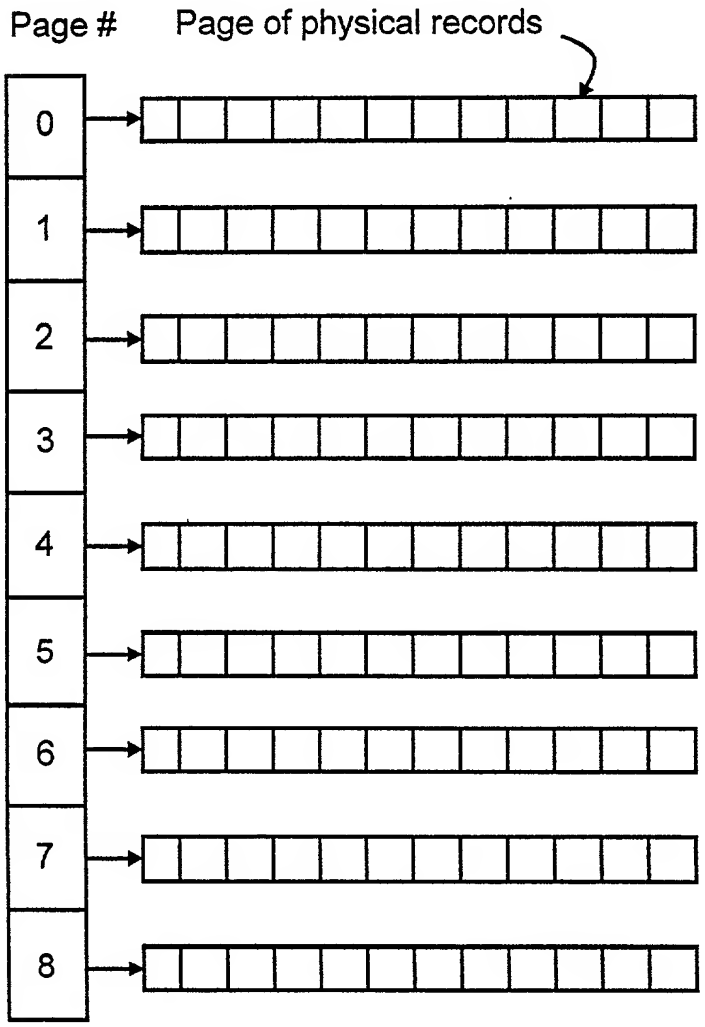


Fig. 2D
(PRIOR ART)

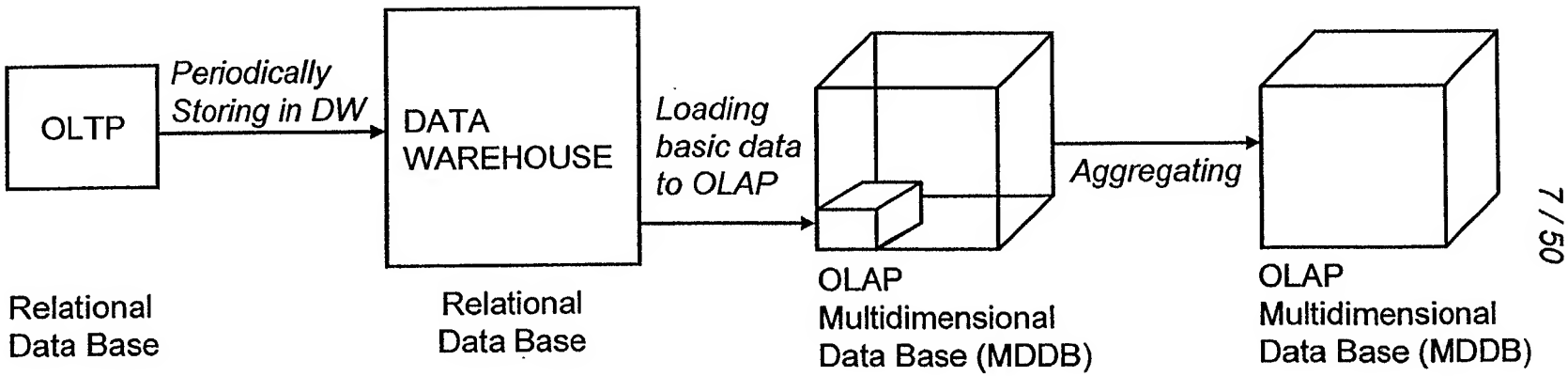


Fig. 3A
(PRIOR ART)

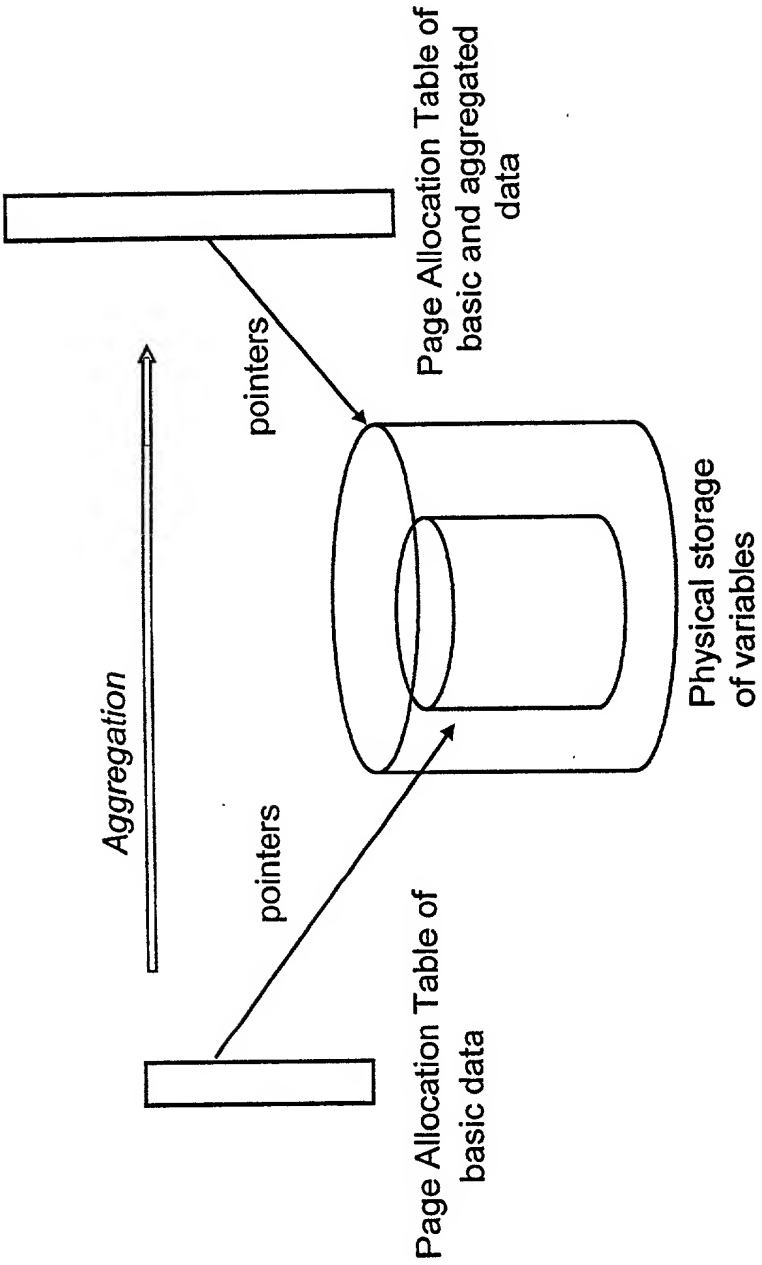


Fig. 3B
(PRIOR ART)

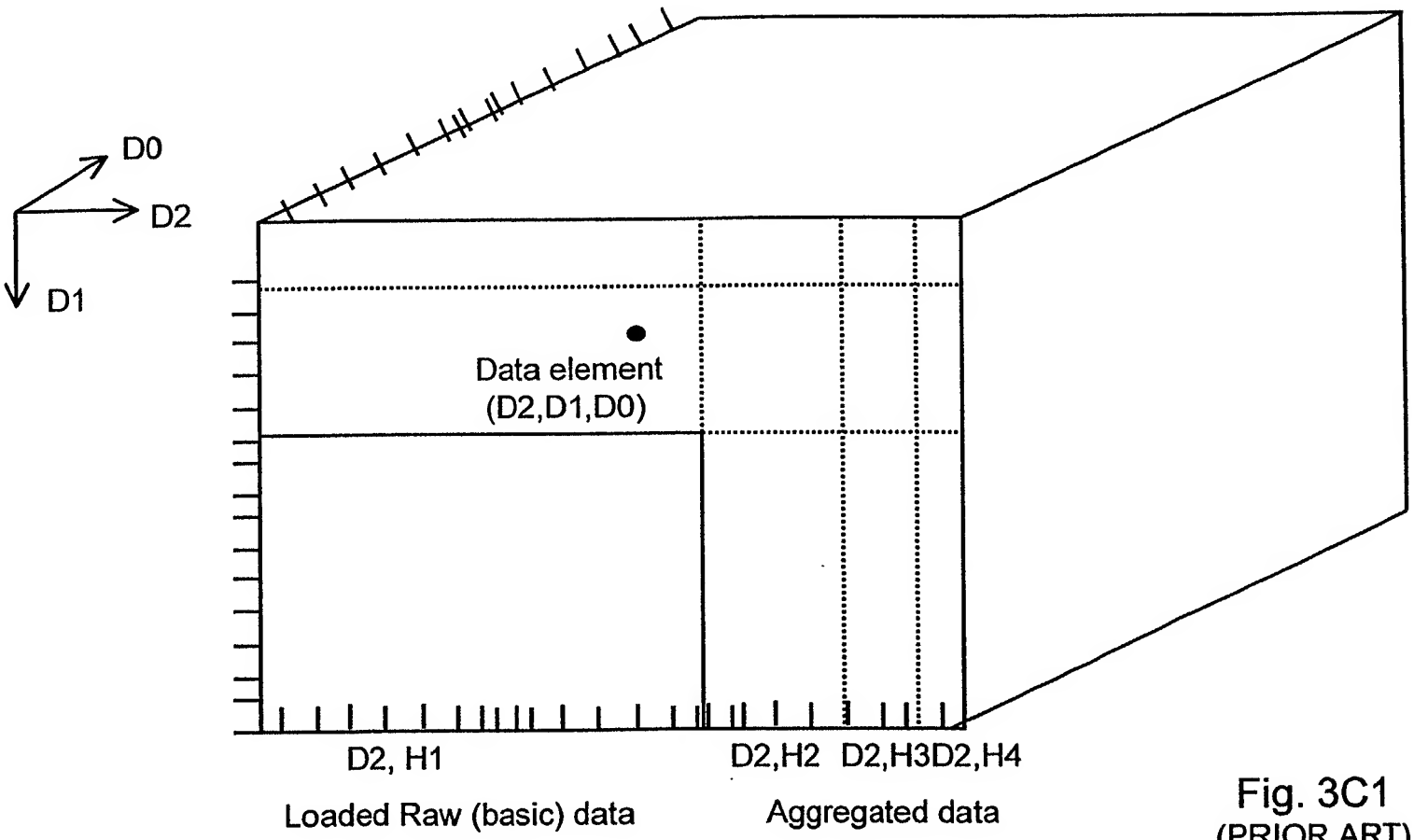
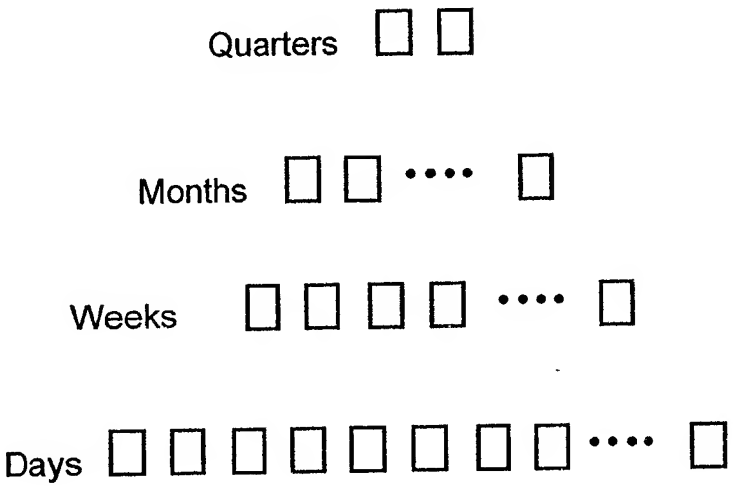
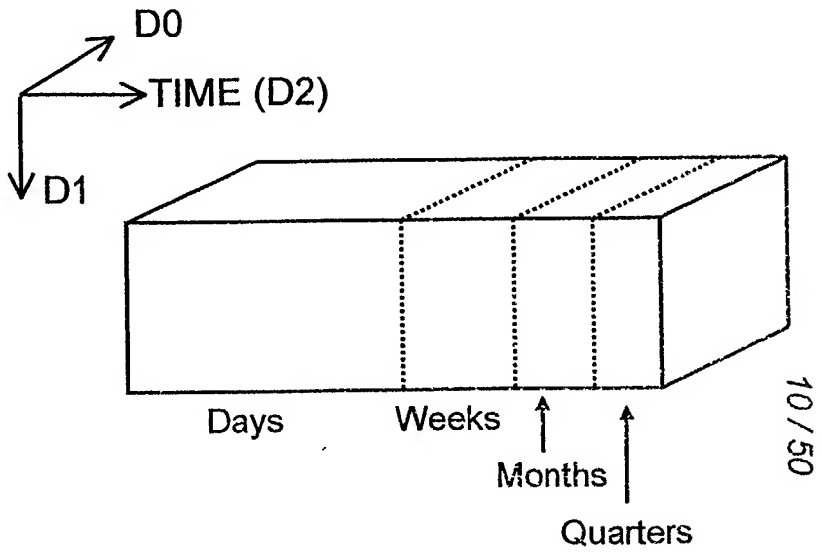


Fig. 3C1
(PRIOR ART)



Hierarchy of TIME dimension

Fig. 3C2
(PRIOR ART)



Spatial occupancy of TIME hierarchy

Fig. 3C3
(PRIOR ART)

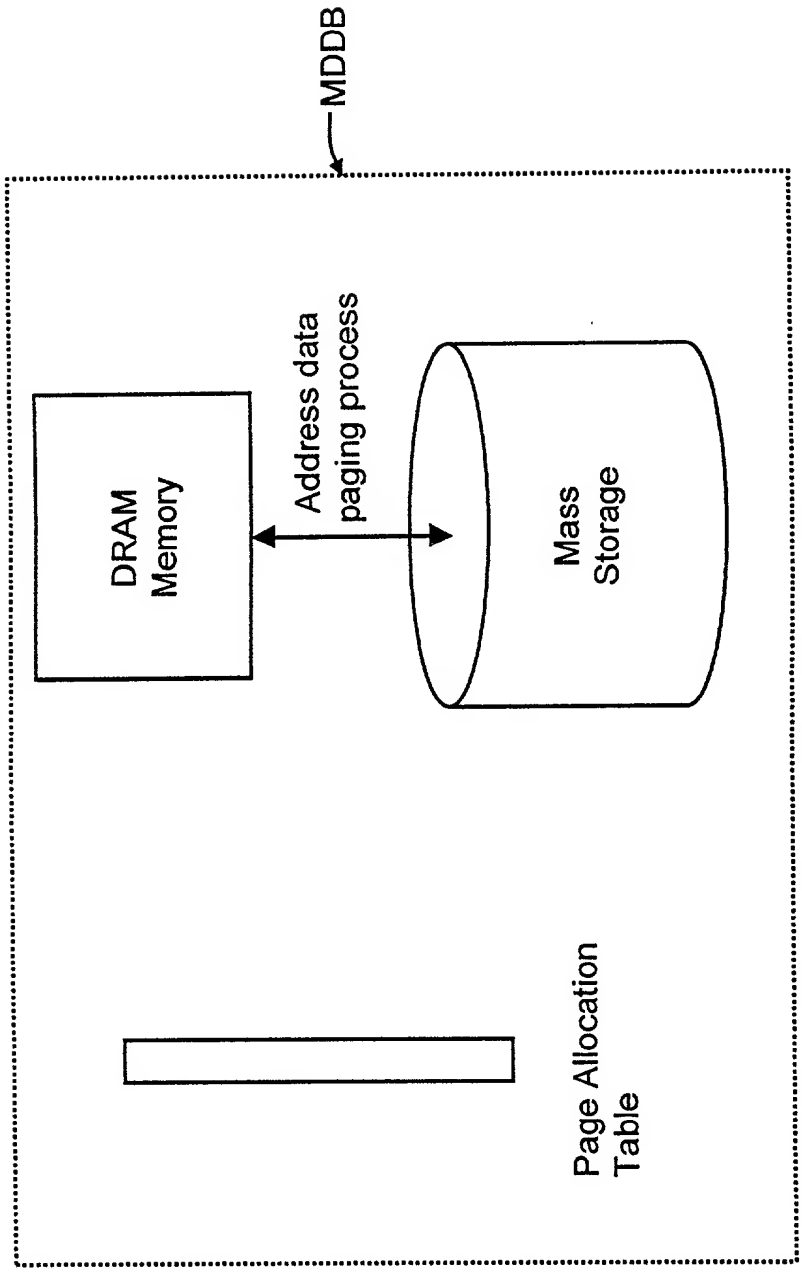


Fig. 4
(PRIOR ART)

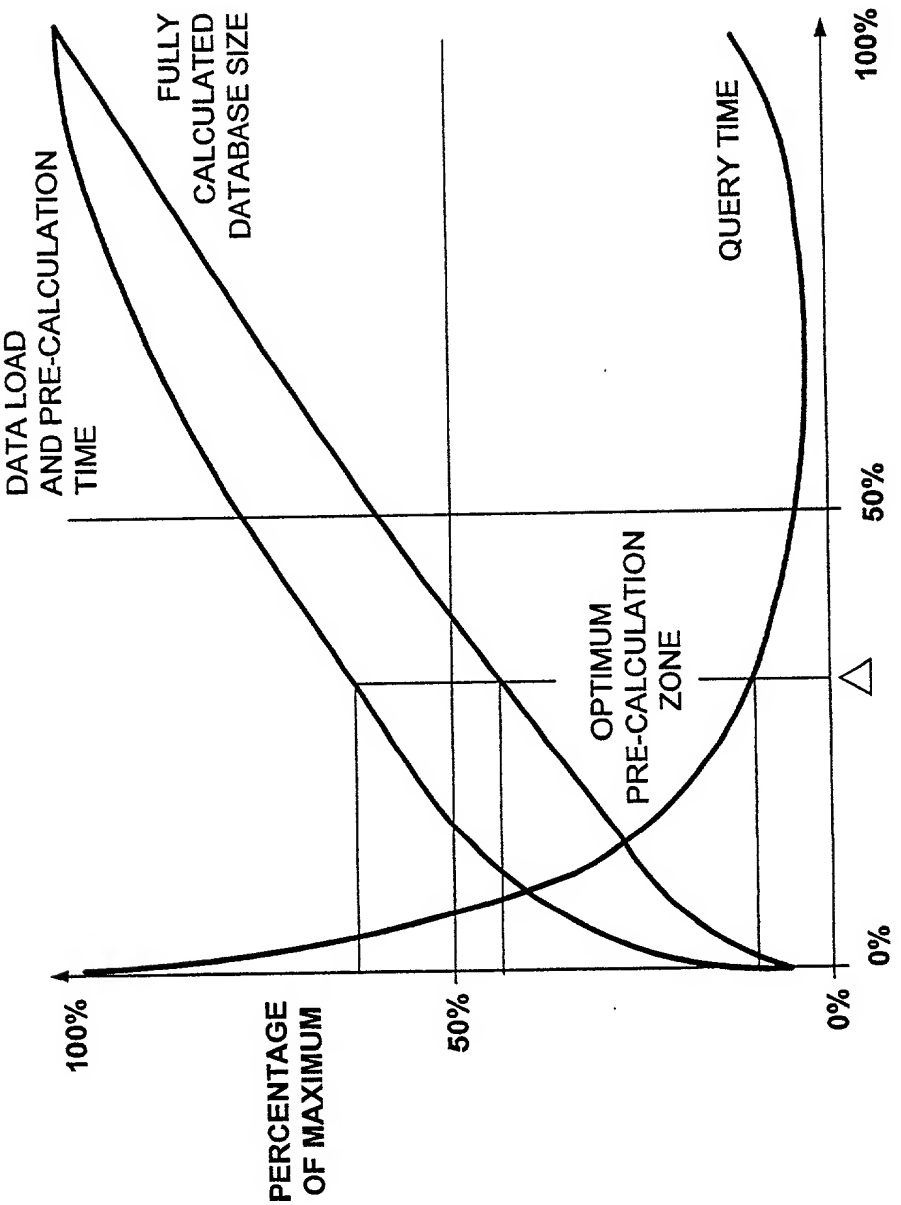


Fig. 5
(PRIOR ART)

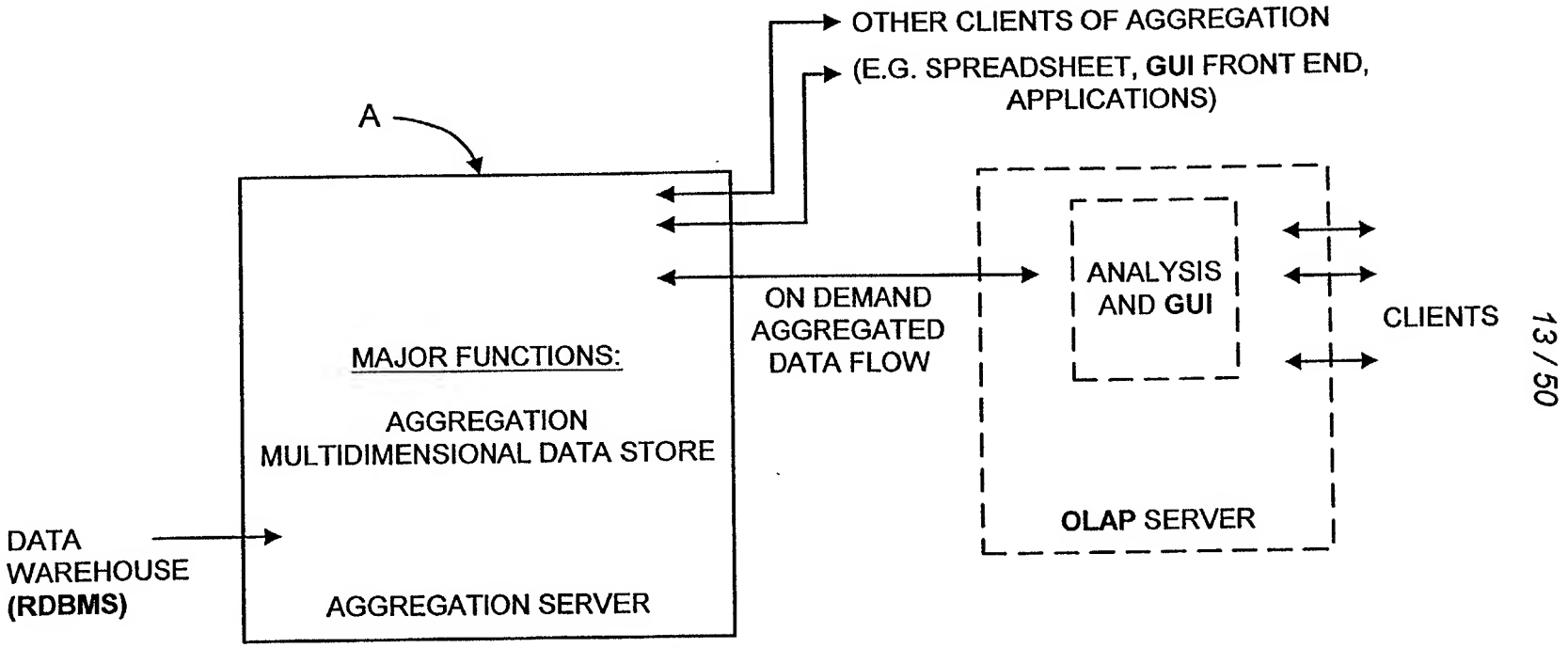

OTHER CLIENTS OF AGGREGATION
(E.G. SPREADSHEET, GUI FRONT END, APPLICATIONS)
A
ON DEMAND AGGREGATED DATA FLOW
ANALYSIS AND GUI
CLIENTS
MAJOR FUNCTIONS:
AGGREGATION MULTIDIMENSIONAL DATA STORE
OLAP SERVER
DATA WAREHOUSE (RDBMS)
AGGREGATION SERVER

FIG. 6A

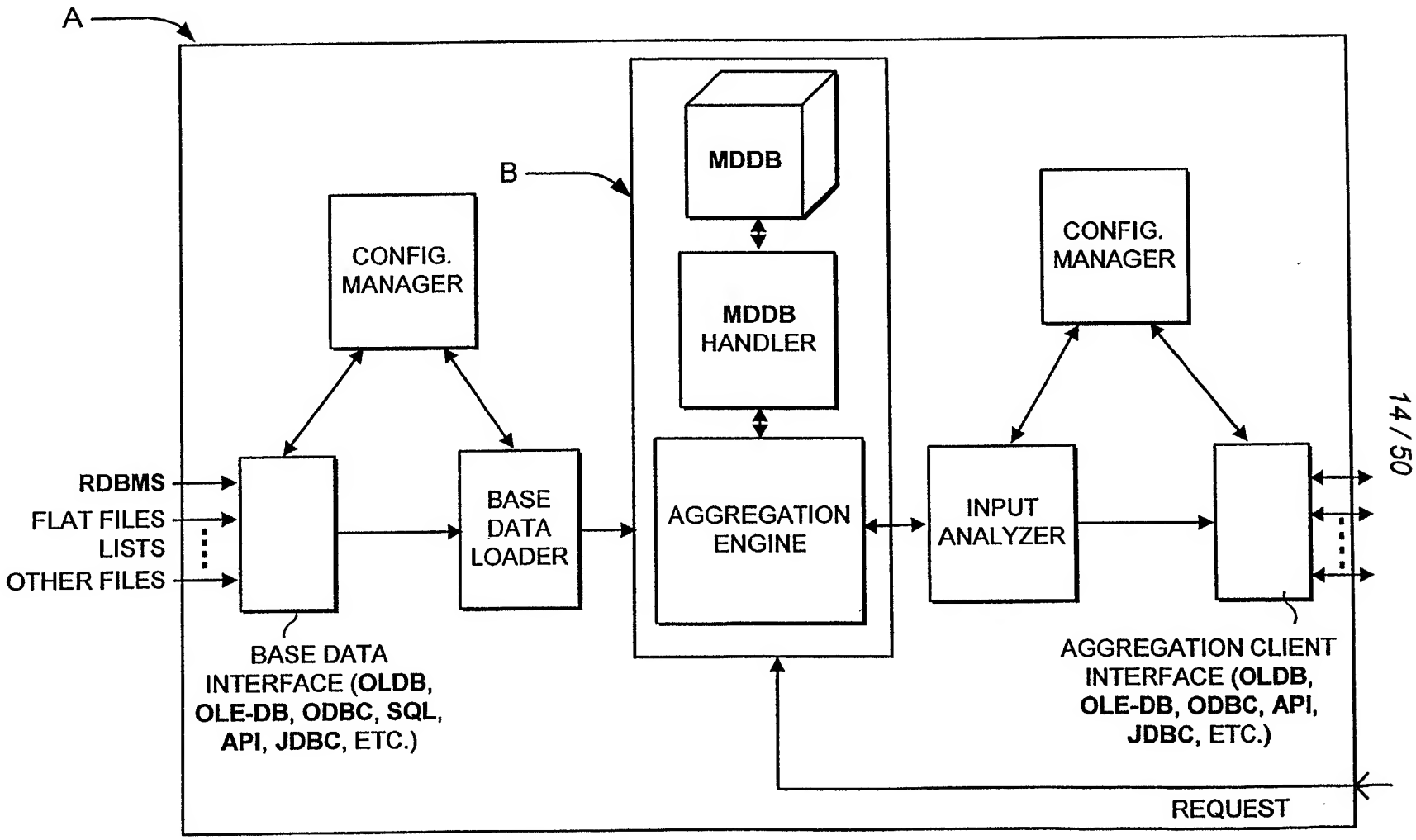

A
B
MDDB
MDDB HANDLER
CONFIG. MANAGER
CONFIG. MANAGER
RDBMS
FLAT FILES
LISTS
OTHER FILES
BASE DATA LOADER
AGGREGATION ENGINE
INPUT ANALYZER
BASE DATA INTERFACE (OLDB, OLE-DB, ODBC, SQL, API, JDBC, ETC.)
AGGREGATION CLIENT INTERFACE (OLDB, OLE-DB, ODBC, API, JDBC, ETC.)
REQUEST

FIG. 6B

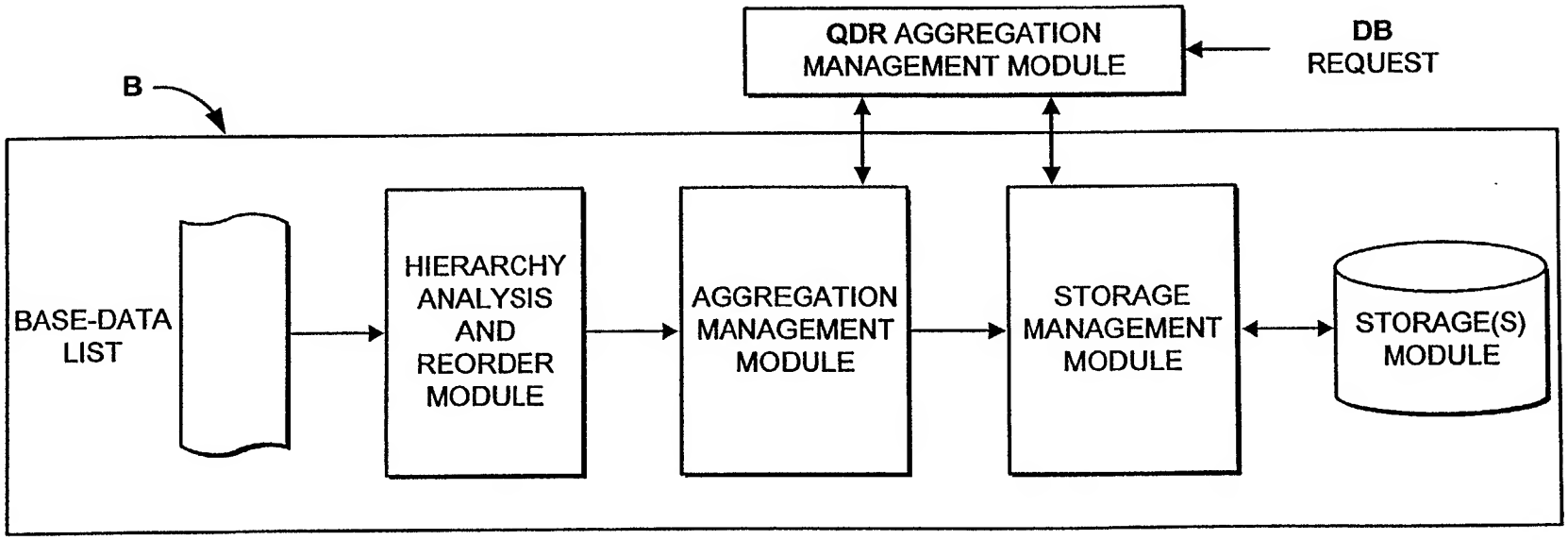

QDR AGGREGATION MANAGEMENT MODULE
DB REQUEST
B
BASE-DATA LIST
HIERARCHY ANALYSIS AND REORDER MODULE
AGGREGATION MANAGEMENT MODULE
STORAGE MANAGEMENT MODULE
STORAGE(S) MODULE

FIG. 6C

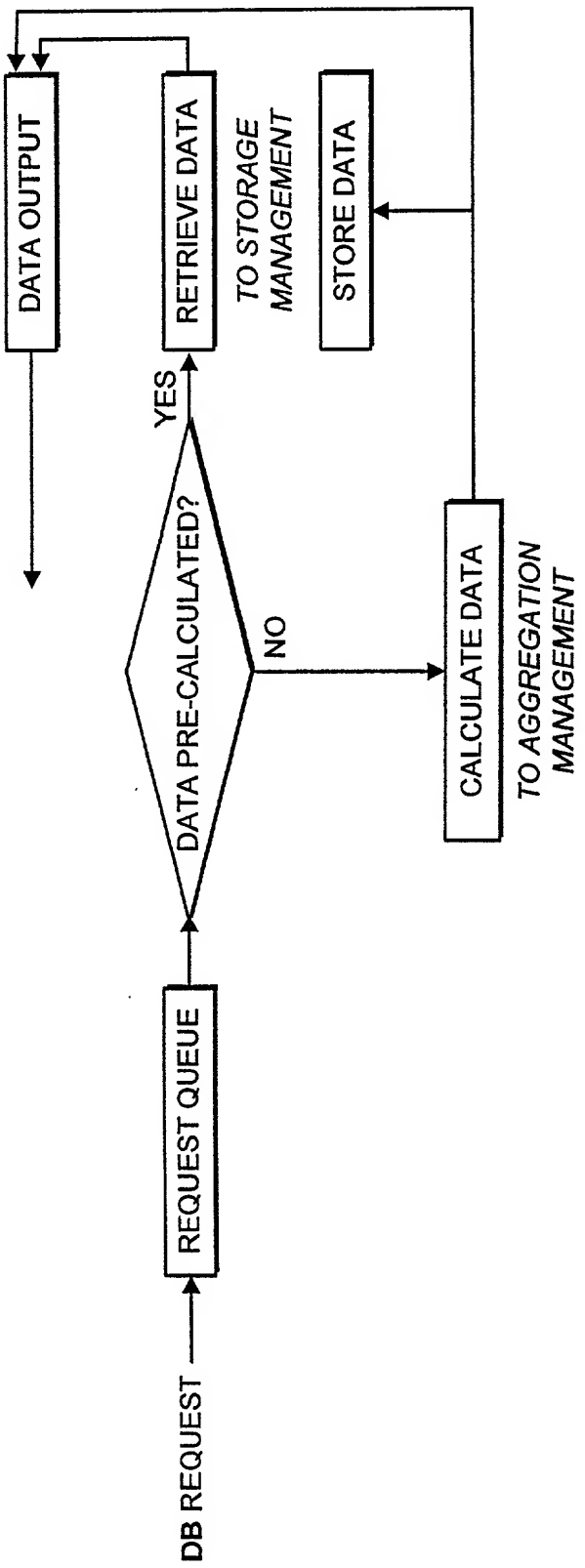

DB REQUEST
REQUEST QUEUE
DATA PRE-CALCULATED?
YES
NO
RETRIEVE DATA
TO STORAGE MANAGEMENT
STORE DATA
CALCULATE DATA
TO AGGREGATION MANAGEMENT
DATA OUTPUT

FIG. 6D

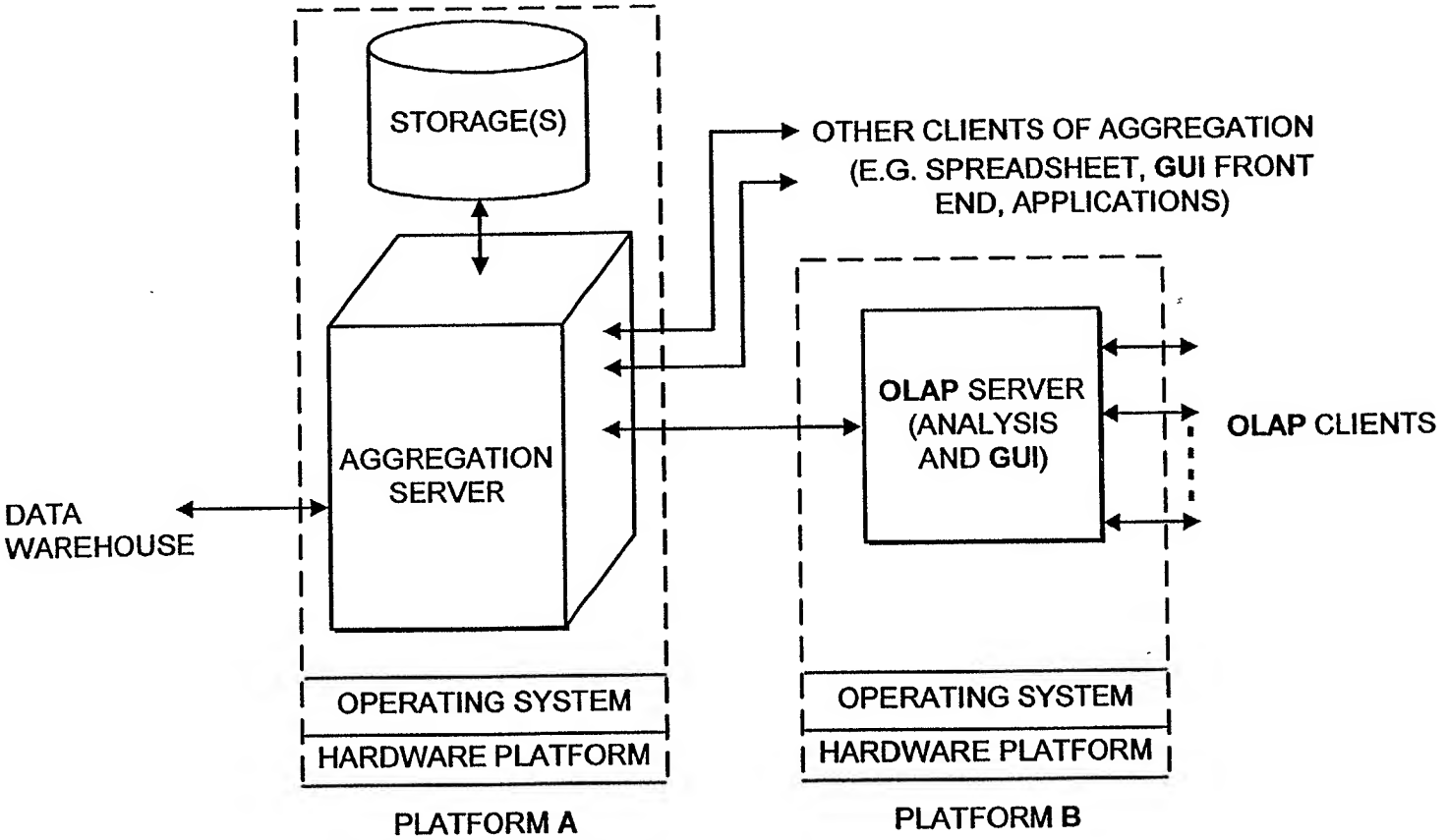


FIG. 7A

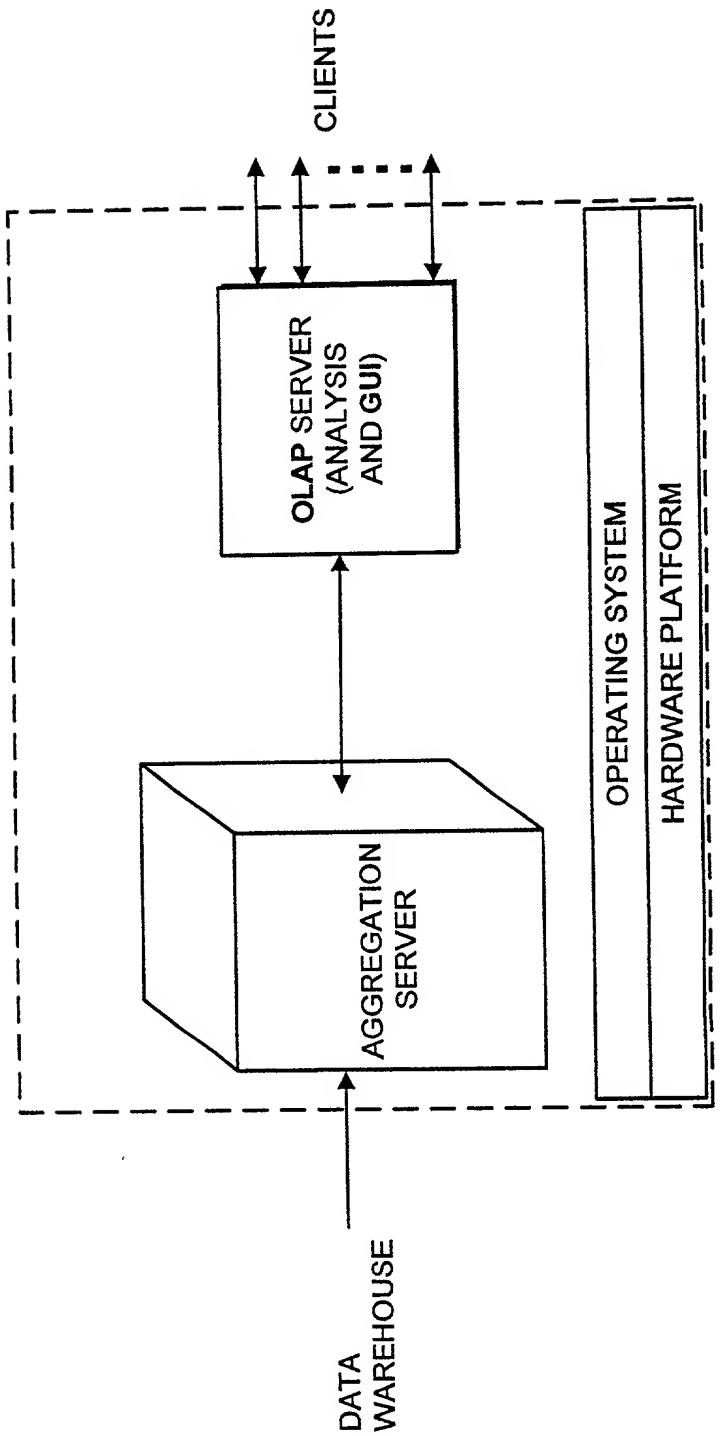

CLIENTS
OLAP SERVER (ANALYSIS AND GUI)
AGGREGATION SERVER
OPERATING SYSTEM
HARDWARE PLATFORM
DATA WAREHOUSE

FIG. 7B

	NBR. OF DIM.	NBR. OF ATOMIC DATA DATA VALUES	LEAF NODE DENSITY %	NUMBER OF VALUES IN CUBE AFTER ROLL-UP	ORACLE **EXPRESS** V. 6.2	IMPLEMENTATION OF CURRENT INVENTION
D1	6	302M	9	427 M	16 h	15 m
D2	4	414M	1.27	969 M	50 m	5 m
D3	5	14,499M	0.03	63,954 M	31 h	1h 23 m
D4	6	623,494M	$8 * 10^{-4}$	7,930 G	EXCEEDS 48 h	2 h 20 m
D5	6	243,000M	10^{-8}	1,160,000 G	22 h	4 m
D6	4	7M	DEFINED AS 100	19 M	15 m	1 m

FIG. 8A

FIG. 9A

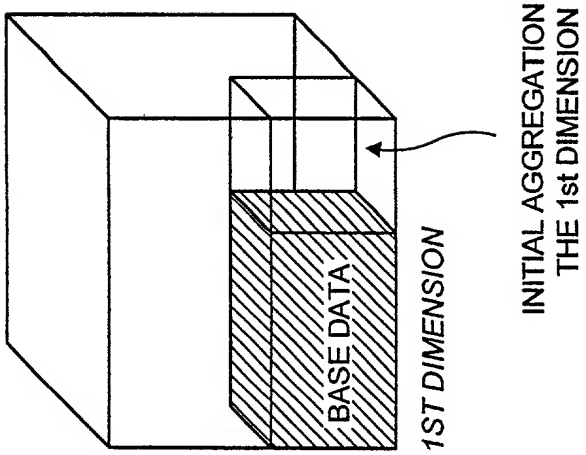
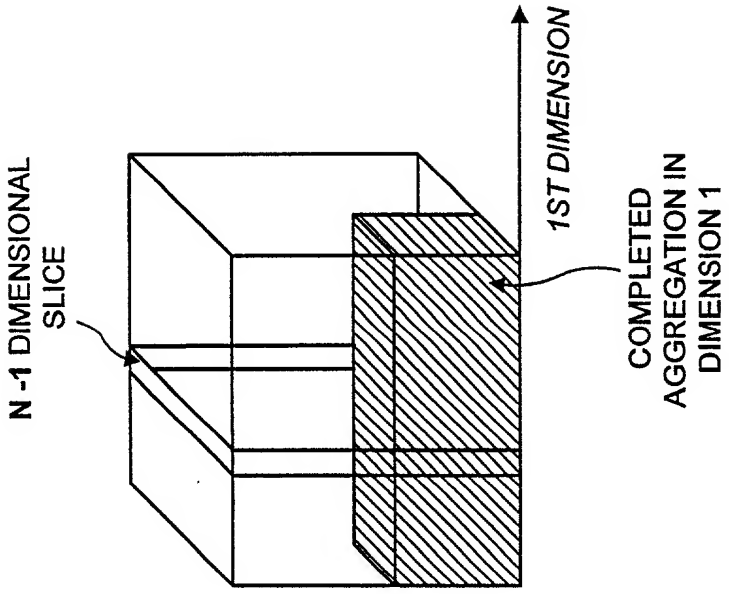
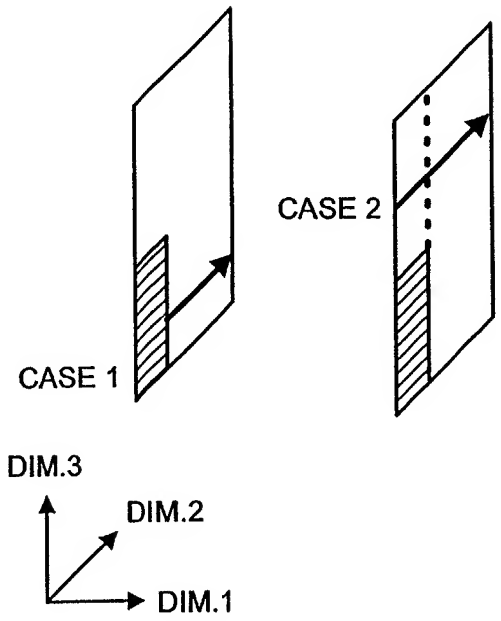

INITIAL AGGREGATION IN
THE 1st DIMENSION
BASE DATA
1ST DIMENSION

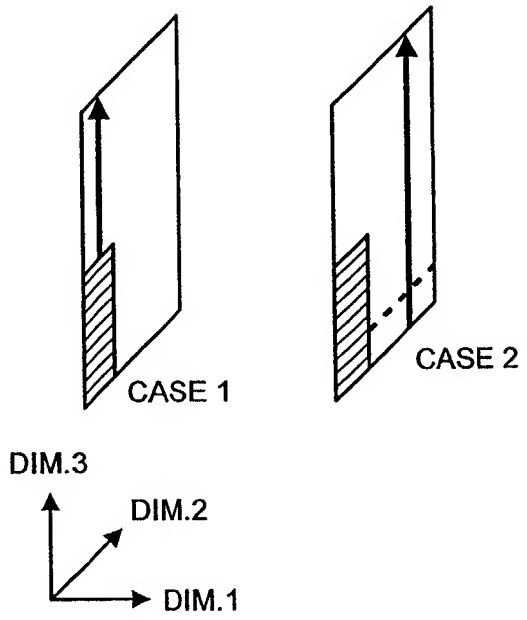
FIG. 9B


N -1 DIMENSIONAL SLICE
1ST DIMENSION
COMPLETED AGGREGATION IN DIMENSION 1



A. DIRECTED AGGREGATION IN DIMENSION 2, CASES 1 AND 2

F I G. 9C1



A. DIRECTED AGGREGATION IN DIMENSION 3, CASES 1 AND 2

F I G. 9C2

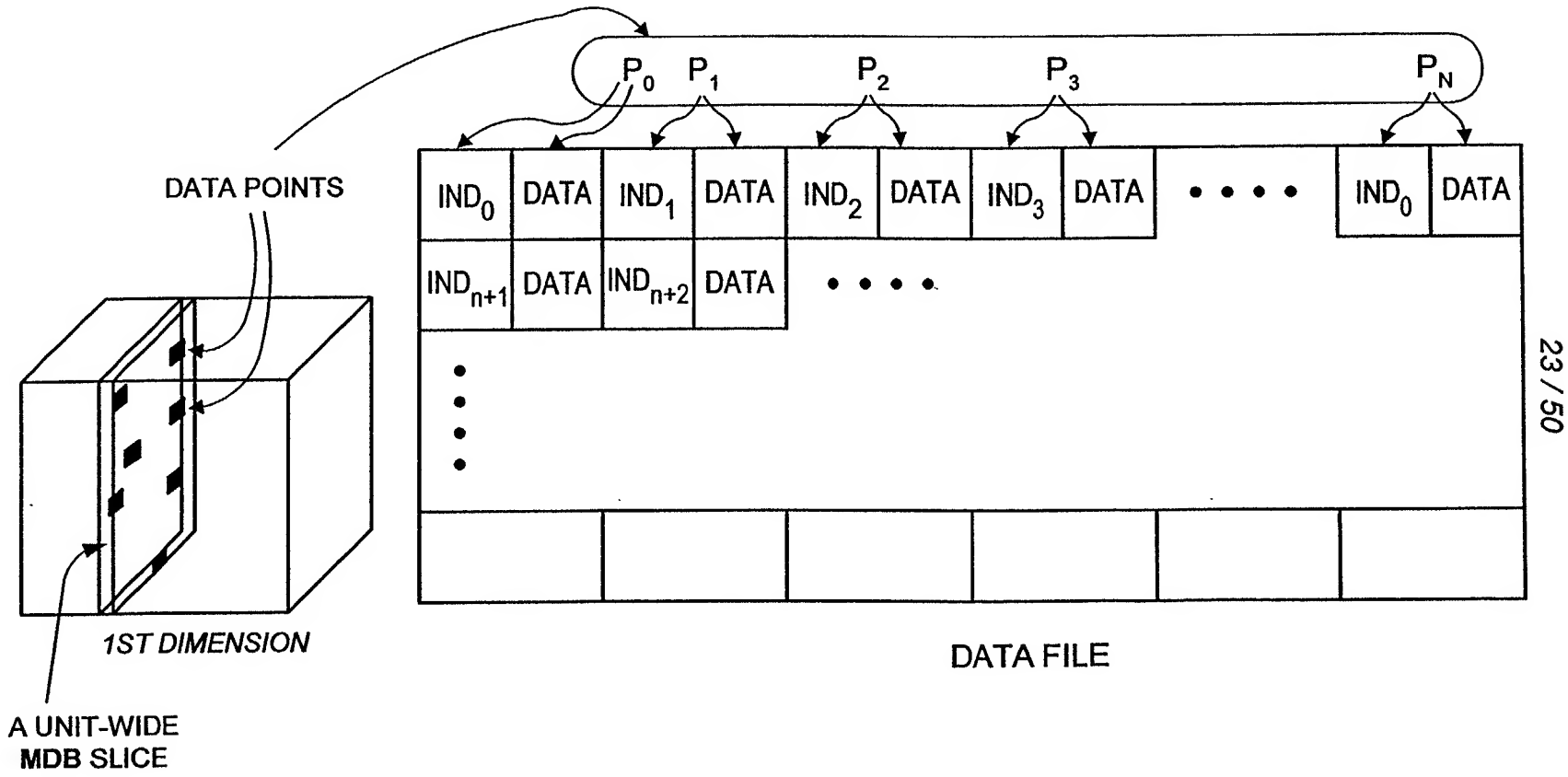

P0
P1
P2
P3
PN
DATA POINTS
IND0
DATA
IND1
DATA
IND2
DATA
IND3
DATA
IND0
DATA
IND n+1
DATA
IND n+2
DATA
1ST DIMENSION
A UNIT-WIDE
MDB SLICE
DATA FILE

FIG. 10A

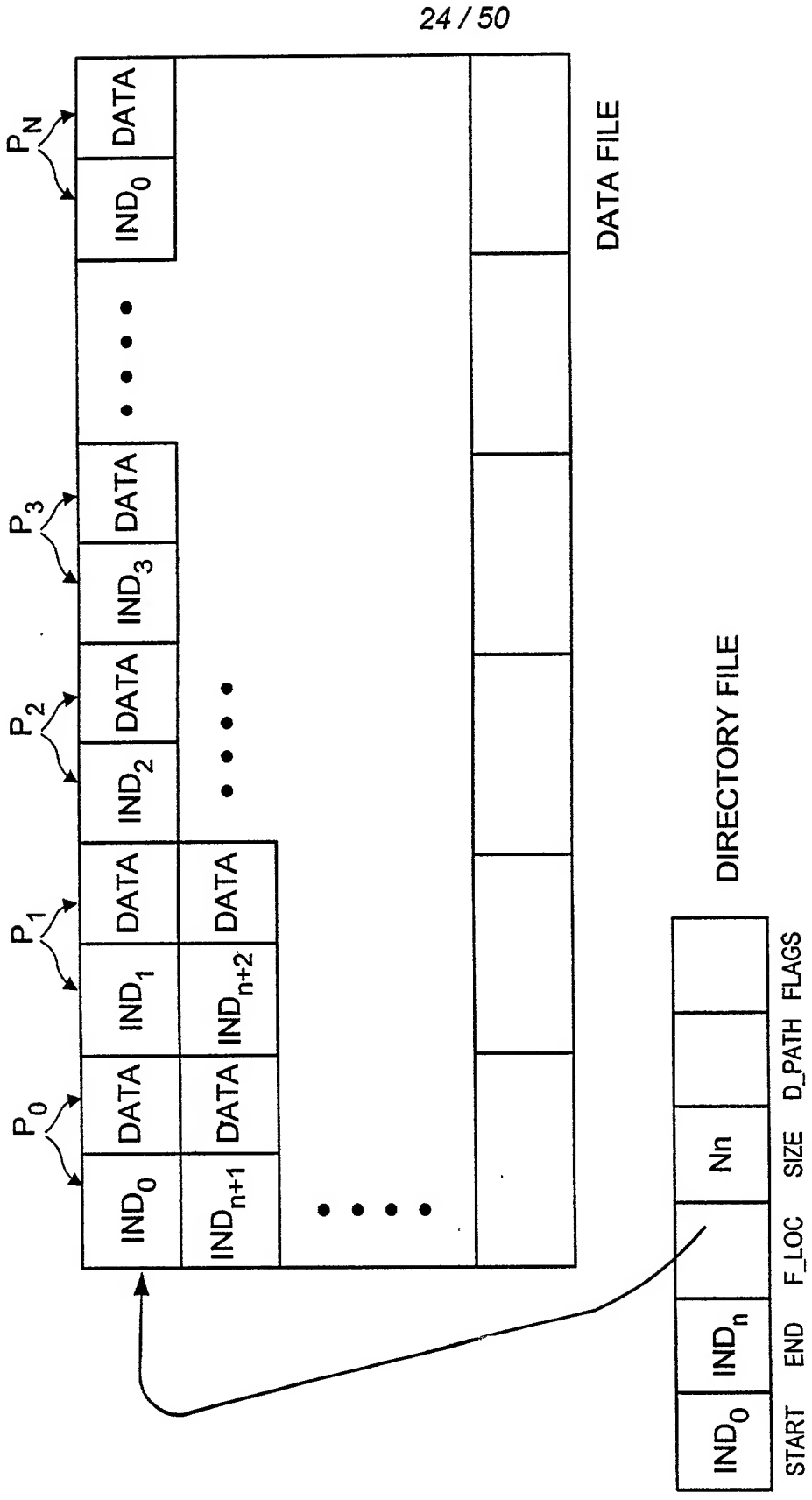
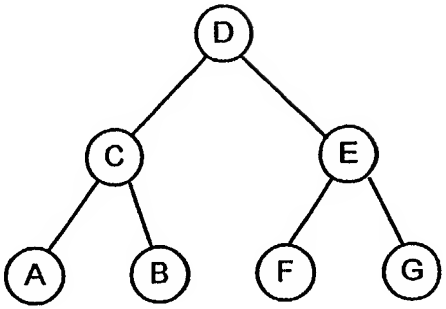
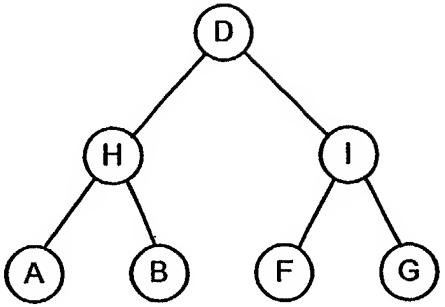

P0
P1
P2
P3
PN
IND0
IND1
IND2
IND3
IND0
DATA
DATA
DATA
DATA
DATA
INDn+1
INDn+2
DATA FILE
DIRECTORY FILE
START
END
F_LOC
SIZE
D_PATH
FLAGS
IND0
INDn
Nn

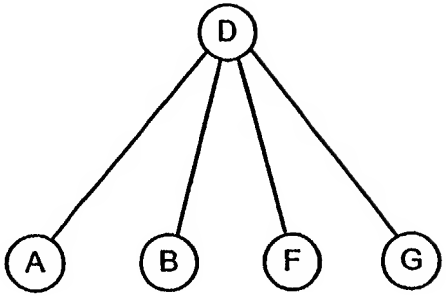
FIG. 10B



STRUCT. 1



STRUCT. 2



STRUCT. 3

FIG. 11A

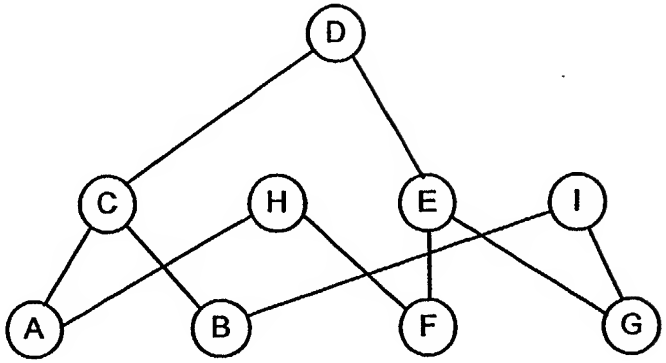


FIG. 11B

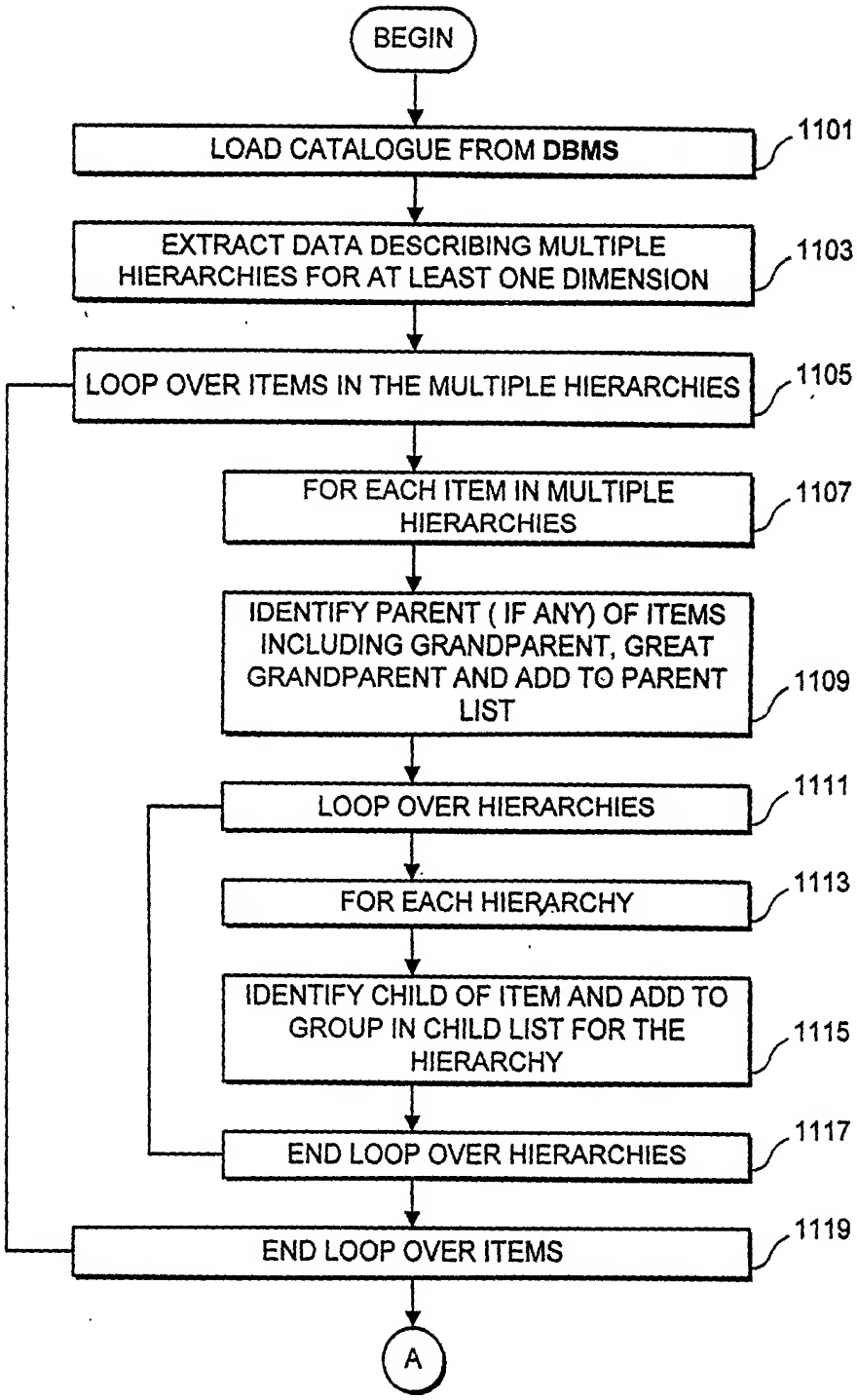
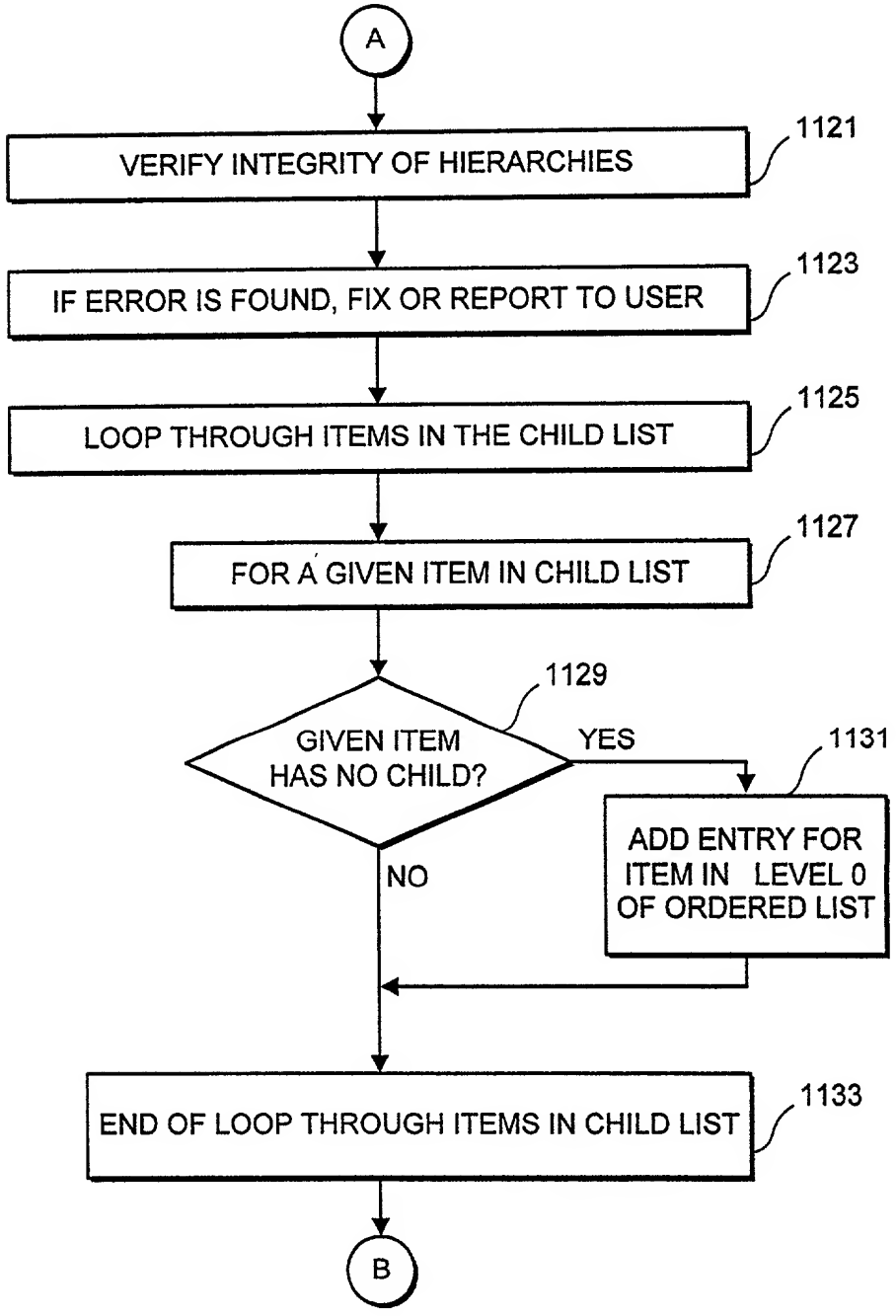
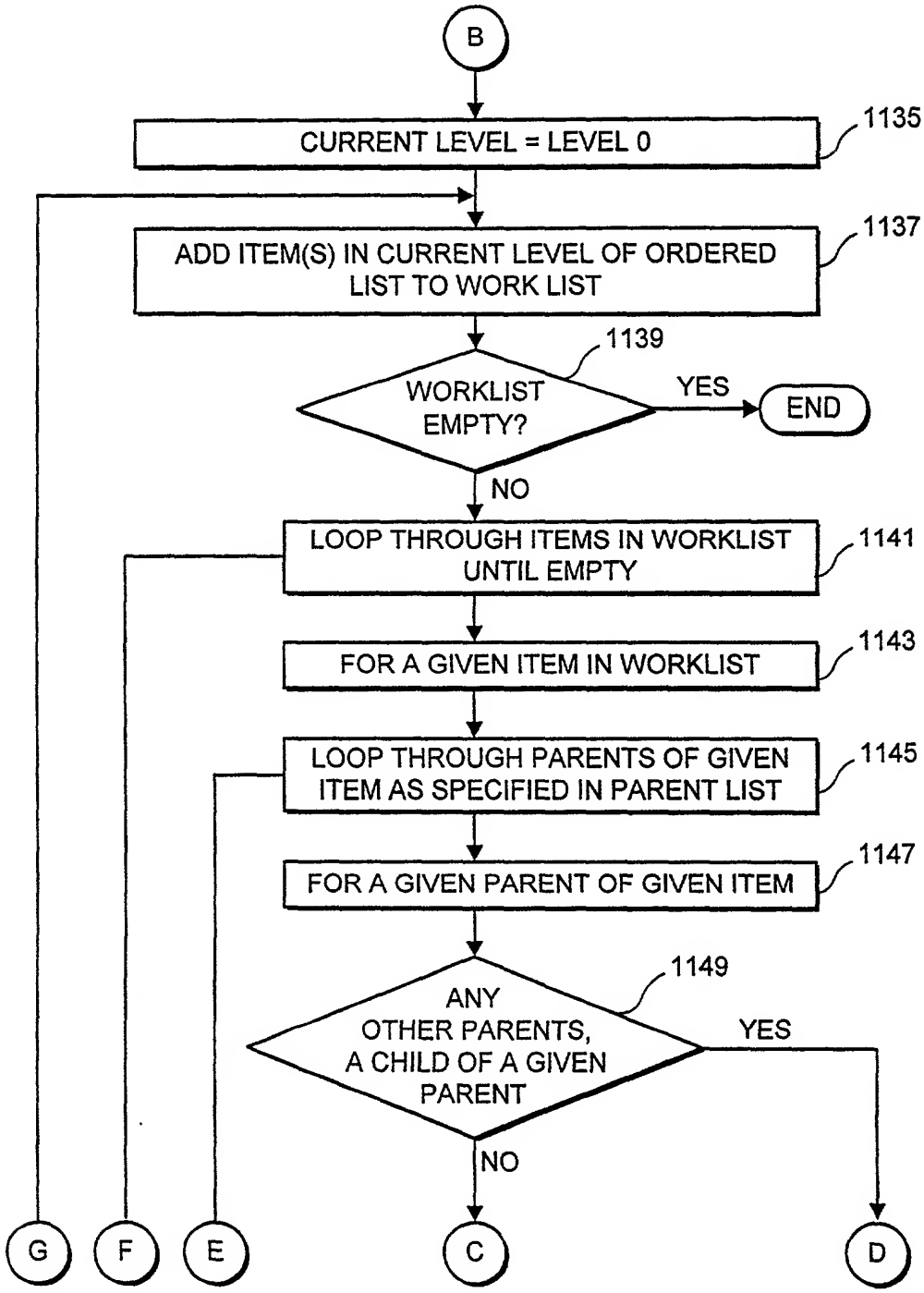

BEGIN
LOAD CATALOGUE FROM DBMS
1101
EXTRACT DATA DESCRIBING MULTIPLE HIERARCHIES FOR AT LEAST ONE DIMENSION
1103
LOOP OVER ITEMS IN THE MULTIPLE HIERARCHIES
1105
FOR EACH ITEM IN MULTIPLE HIERARCHIES
1107
IDENTIFY PARENT (IF ANY) OF ITEMS INCLUDING GRANDPARENT, GREAT GRANDPARENT AND ADD TO PARENT LIST
1109
LOOP OVER HIERARCHIES
1111
FOR EACH HIERARCHY
1113
IDENTIFY CHILD OF ITEM AND ADD TO GROUP IN CHILD LIST FOR THE HIERARCHY
1115
END LOOP OVER HIERARCHIES
1117
END LOOP OVER ITEMS
1119
A

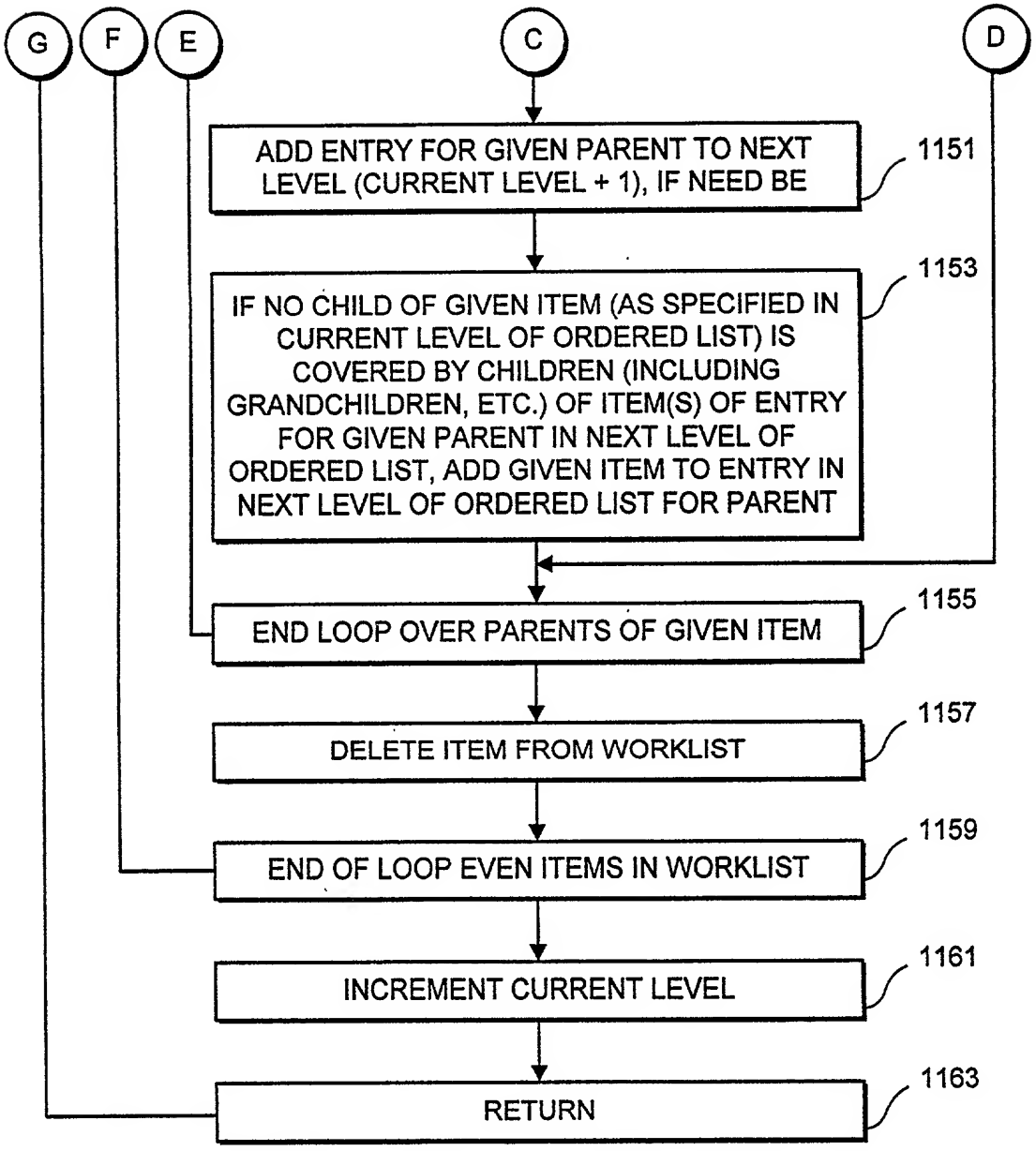
FIG. 11C(i)


A
VERIFY INTEGRITY OF HIERARCHIES
1121
IF ERROR IS FOUND, FIX OR REPORT TO USER
1123
LOOP THROUGH ITEMS IN THE CHILD LIST
1125
FOR A GIVEN ITEM IN CHILD LIST
1127
GIVEN ITEM HAS NO CHILD?
1129
YES
1131
ADD ENTRY FOR ITEM IN LEVEL 0 OF ORDERED LIST
NO
END OF LOOP THROUGH ITEMS IN CHILD LIST
1133
B

F I G. 11C(ii)


B
CURRENT LEVEL = LEVEL 0
1135
ADD ITEM(S) IN CURRENT LEVEL OF ORDERED LIST TO WORK LIST
1137
1139
WORKLIST EMPTY?
YES
END
NO
LOOP THROUGH ITEMS IN WORKLIST UNTIL EMPTY
1141
FOR A GIVEN ITEM IN WORKLIST
1143
LOOP THROUGH PARENTS OF GIVEN ITEM AS SPECIFIED IN PARENT LIST
1145
FOR A GIVEN PARENT OF GIVEN ITEM
1147
1149
ANY OTHER PARENTS, A CHILD OF A GIVEN PARENT
YES
NO
G
F
E
C
D

F I G. 11C(iii)


G
F
E
C
D
ADD ENTRY FOR GIVEN PARENT TO NEXT LEVEL (CURRENT LEVEL + 1), IF NEED BE
1151
IF NO CHILD OF GIVEN ITEM (AS SPECIFIED IN CURRENT LEVEL OF ORDERED LIST) IS COVERED BY CHILDREN (INCLUDING GRANDCHILDREN, ETC.) OF ITEM(S) OF ENTRY FOR GIVEN PARENT IN NEXT LEVEL OF ORDERED LIST, ADD GIVEN ITEM TO ENTRY IN NEXT LEVEL OF ORDERED LIST FOR PARENT
1153
END LOOP OVER PARENTS OF GIVEN ITEM
1155
DELETE ITEM FROM WORKLIST
1157
END OF LOOP EVEN ITEMS IN WORKLIST
1159
INCREMENT CURRENT LEVEL
1161
RETURN
1163

F I G. 11C(iv)

PARENT LIST

ITEM	PARENT(S)
A	C, H, D
B	C, I, D
F	E, H, D
G	E, I, D
C	D
H	D
E	D
I	D
D	—

F I G. 11C(v)

CHILD LIST

ITEM	CHILD(REN)
A	—
B	—
F	—
G	—
C	<A, B>
H	<F, G>
E	<A, F>
I	<B, G>
D	<A, B, F, G>, <H, I>, <C, E>

F I G. 11C(vi)

ORDERED LIST
LEVEL 0

ITEM	CHILD(REN)
A	—
B	—
F	—
G	—

F I G. 11C(vii)

ORDERED LIST
LEVEL 1

ITEM	CHILD(REN)
C	A, B
H	A, F
I	B, G
E	F, G

F I G. 11C(viii)

ORDERED LIST
LEVEL 2

ITEM	CHILD(REN)
D	C, E

F I G. 11C(ix)

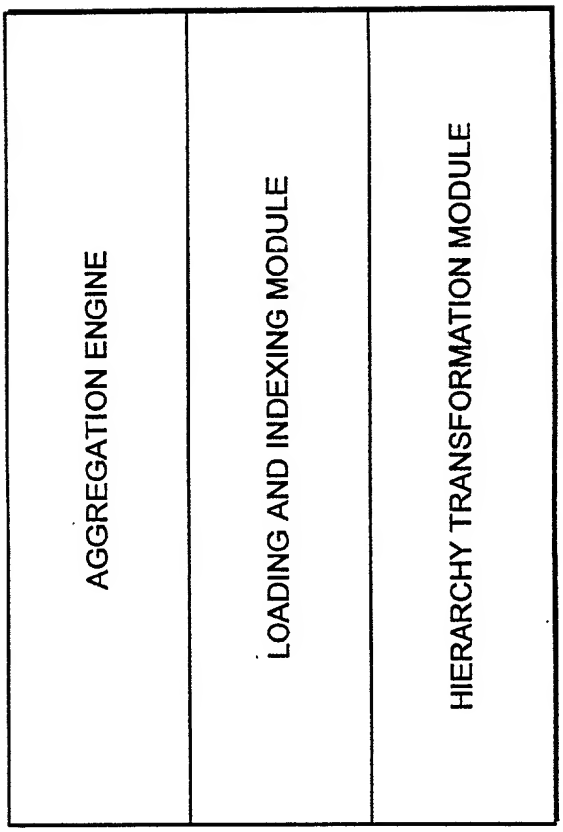
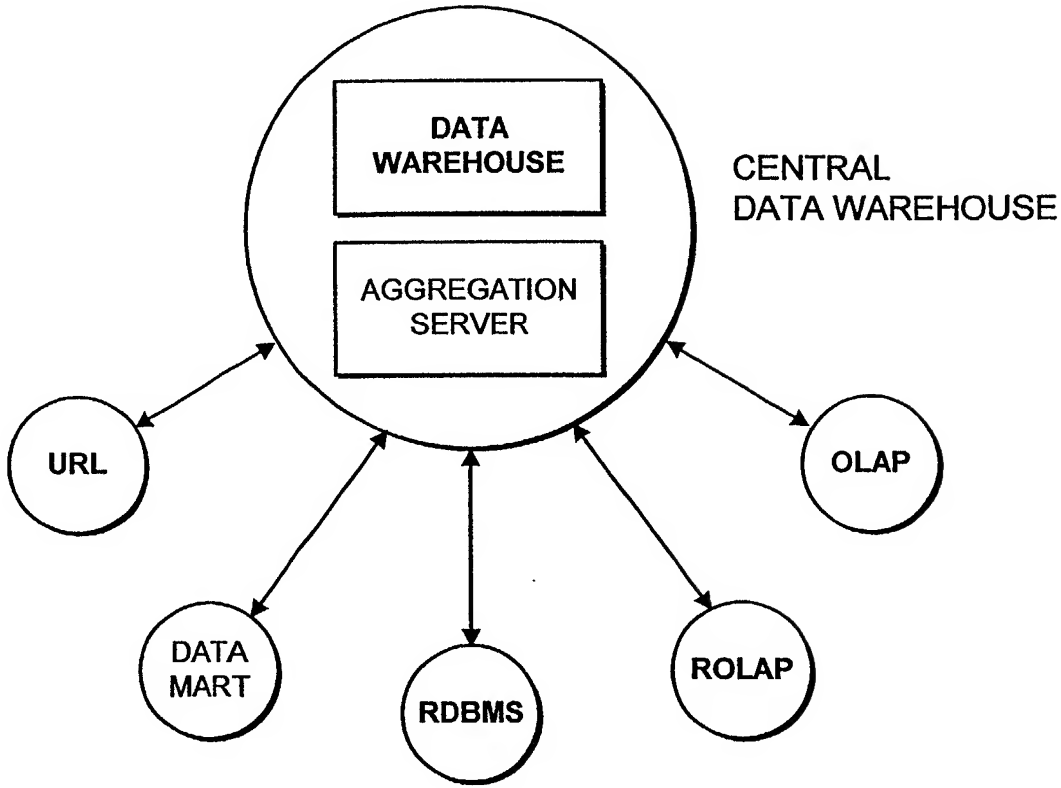
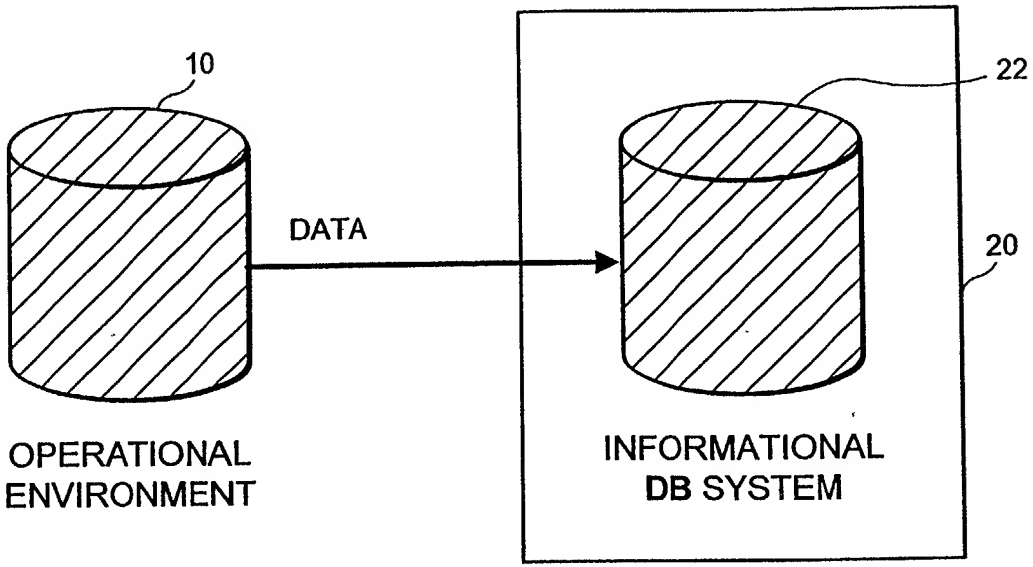

AGGREGATION ENGINE
LOADING AND INDEXING MODULE
HIERARCHY TRANSFORMATION MODULE

FIG. 12



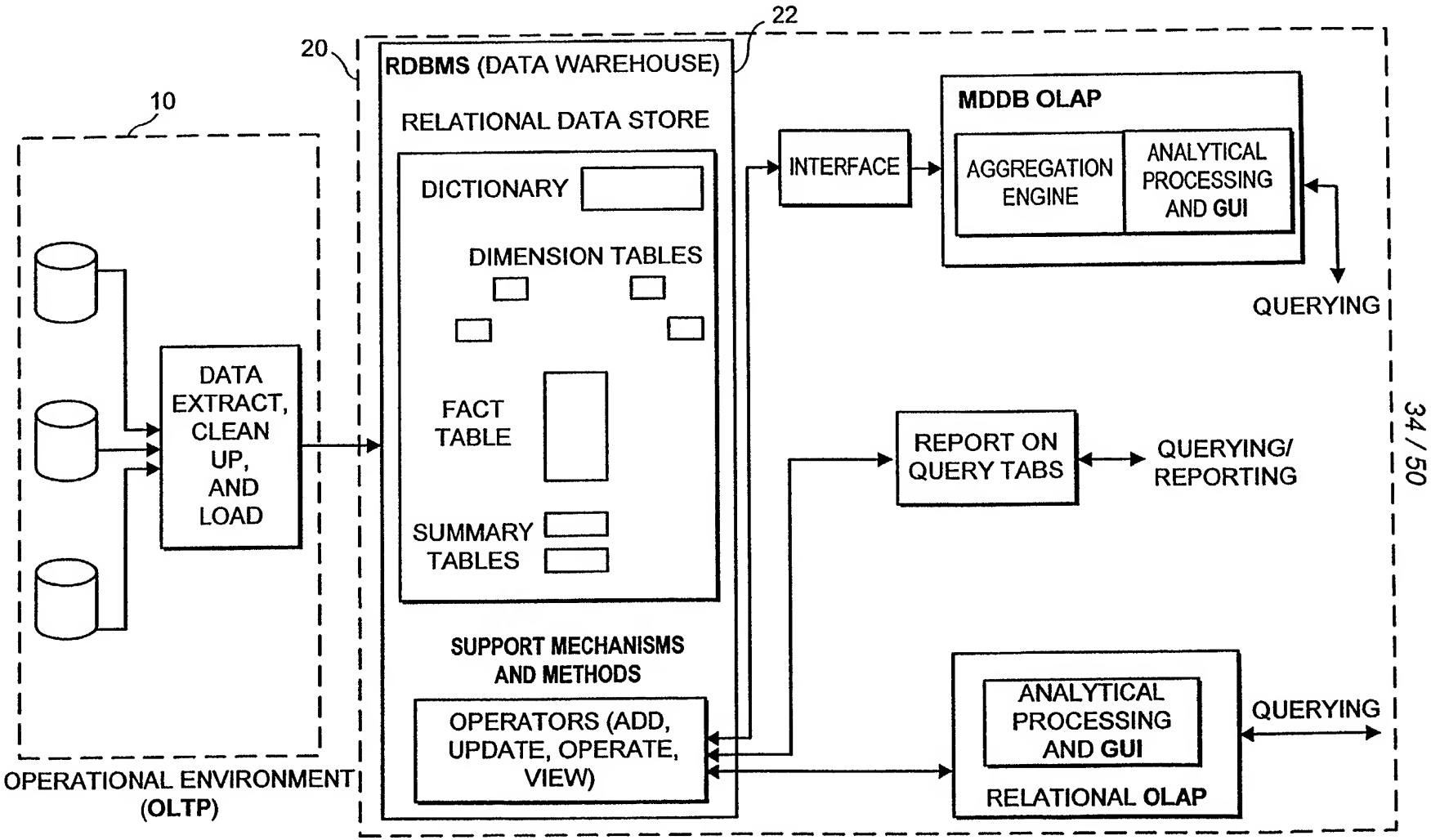
F I G. 13



CONTINUOUS DATA
ON-LINE PROCESSED DATA
NORMALIZED DATA

SNAP-SHOTS
EXTRACT PROCESSING (COPIED DATA)
DATA WAREHOUSE
DATA MARTS
OLAP
DATA MINING
EC-ENABLED WEB SERVERS
EDI B-2-B EXCHANGE
DE-NORMALIZED DATA

F I G. 14 (PRIOR ART)



F I G. 15 (PRIOR ART)

CELLAR

WINE	YEAR	BOTTLES
CHARDONNAY	1996	4
FUME BLANK	1996	2
PINOT NOIR	1993	3
ZINFANDEL	1994	9

FIG. 16A

RESTRICT: OPERATOR:

SELECT WINE, YEAR,
BOTTLES FROM CELLAR
WHERE YEAR IS > 1995;

RESULT

WINE	YEAR	BOTTLES
CHARDONNAY	1996	4
FUME BLANK	1996	2

FIG. 16B

PROJECT: OPERATOR:

SELECT WINE, BOTTLES
FROM CELLAR;

RESULT

WINE	BOTTLES
CHARDONNAY	4
FUME BLANK	2
PINOT NOIR	3
ZINFANDEL	9

FIG. 16C

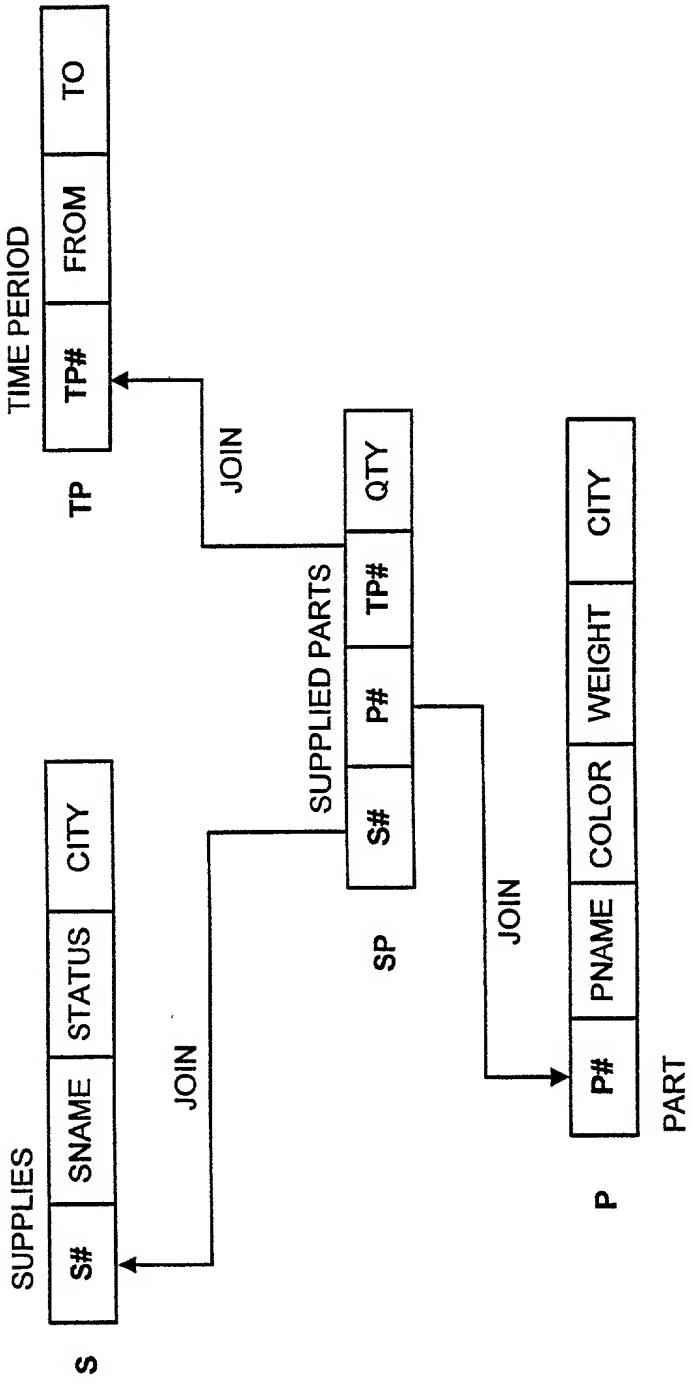

S
SUPPLIES
S#
SNAME
STATUS
CITY
JOIN
SP
SUPPLIED PARTS
S#
P#
TP#
QTY
JOIN
TP
TIME PERIOD
TP#
FROM
TO
JOIN
P
PART
P#
PNAME
COLOR
WEIGHT
CITY

FIG. 17A

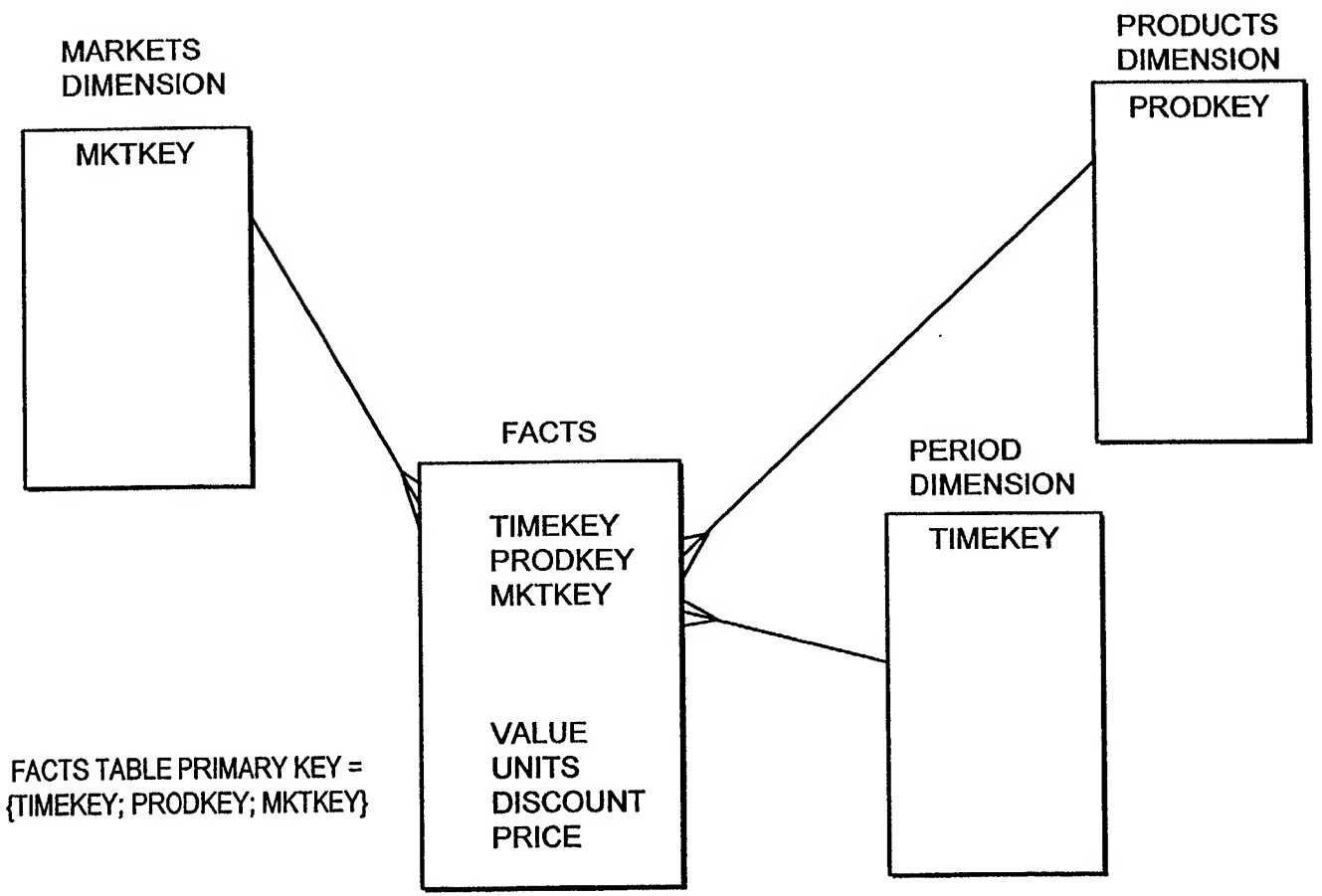

MARKETS
DIMENSION
MKTKEY
PRODUCTS
DIMENSION
PRODKEY
FACTS
TIMEKEY
PRODKEY
MKTKEY
VALUE
UNITS
DISCOUNT
PRICE
PERIOD
DIMENSION
TIMEKEY
FACTS TABLE PRIMARY KEY =
{TIMEKEY; PRODKEY; MKTKEY}

FIG. 18A

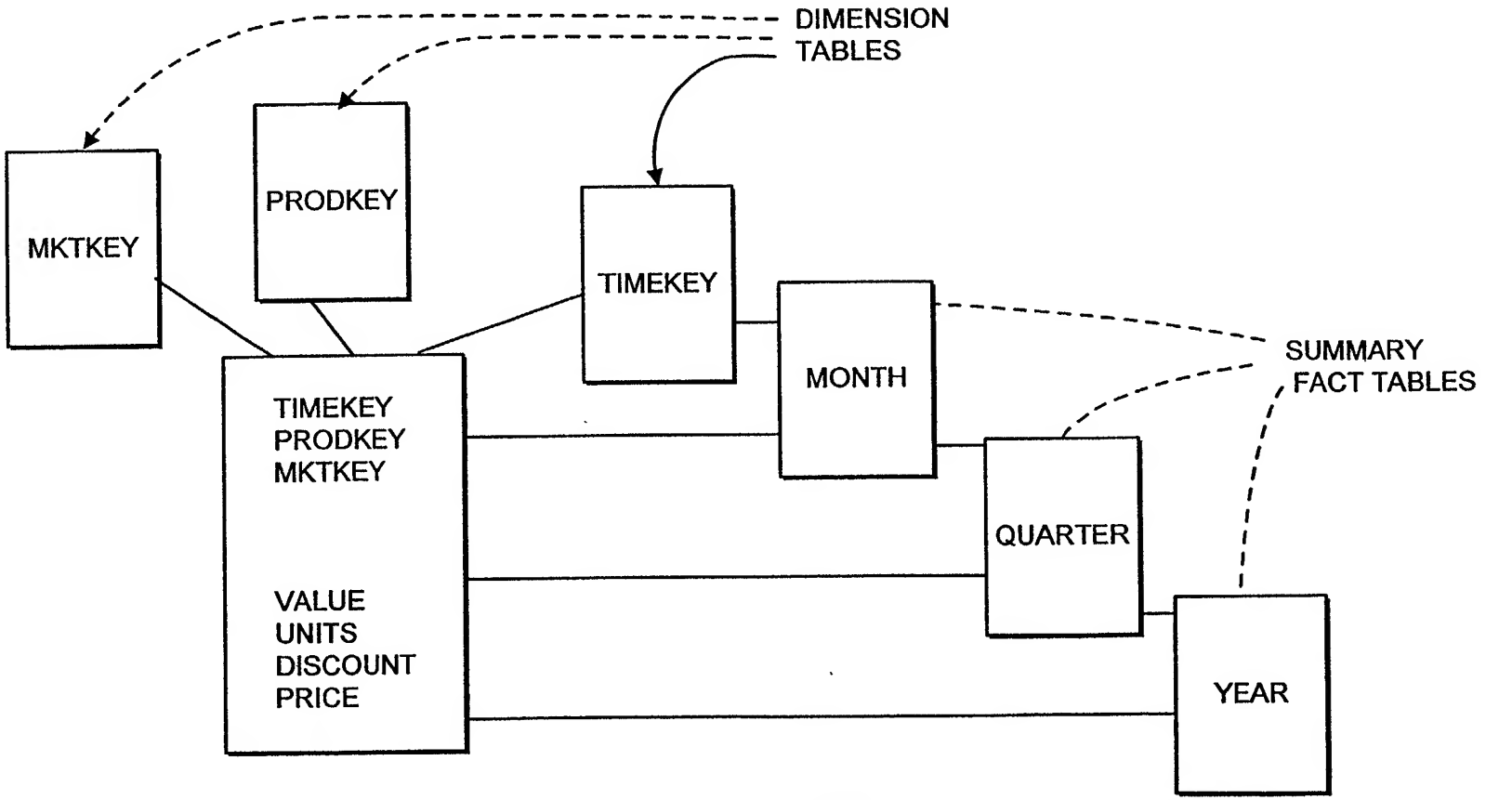

DIMENSION
TABLES
MKTKEY
PRODKEY
TIMEKEY
MONTH
SUMMARY
FACT TABLES
TIMEKEY
PRODKEY
MKTKEY
VALUE
UNITS
DISCOUNT
PRICE
QUARTER
YEAR

FIG. 18B

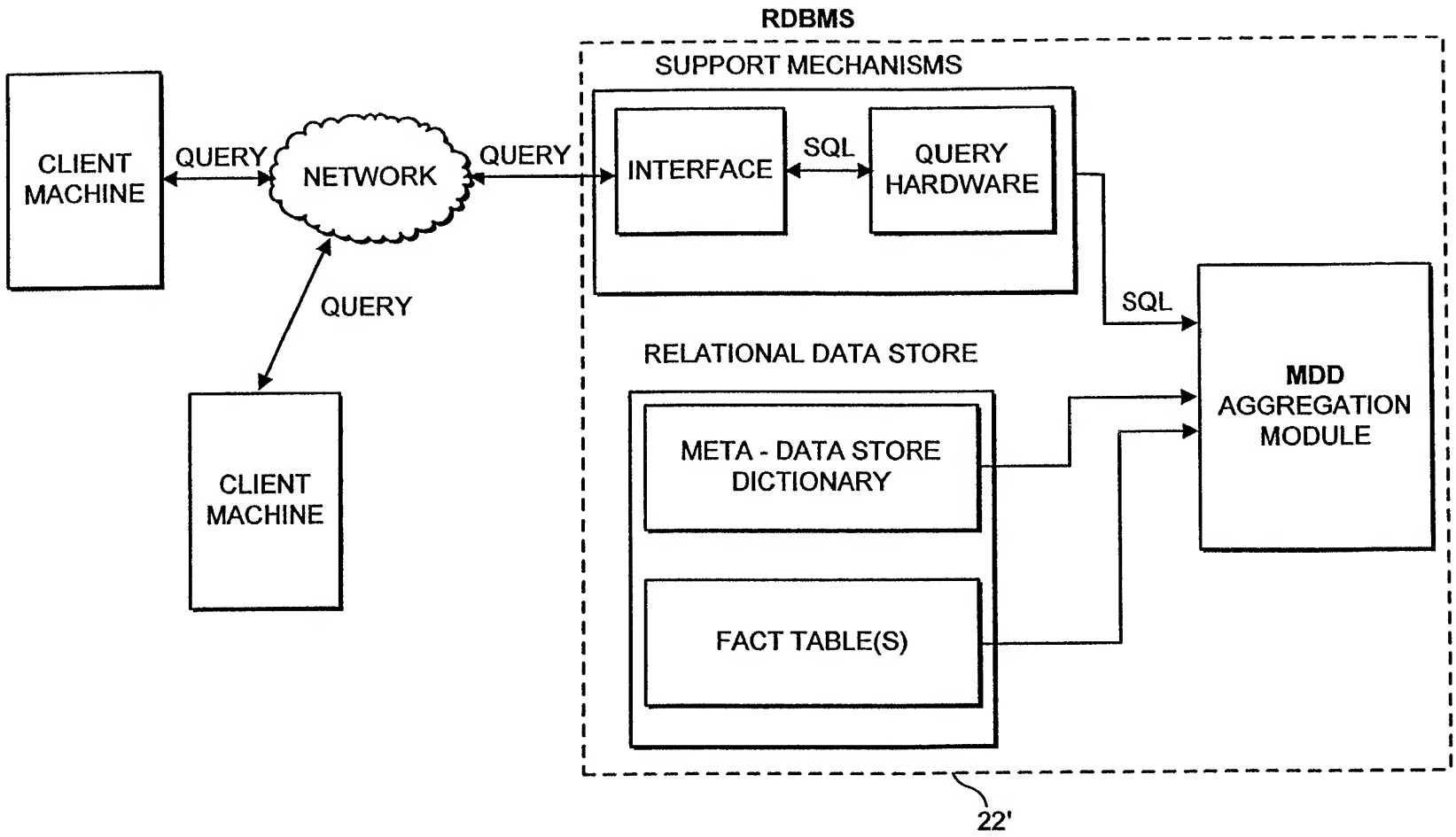

RDBMS
SUPPORT MECHANISMS
CLIENT MACHINE
QUERY
NETWORK
QUERY
INTERFACE
SQL
QUERY HARDWARE
QUERY
SQL
RELATIONAL DATA STORE
MDD AGGREGATION MODULE
CLIENT MACHINE
META - DATA STORE DICTIONARY
FACT TABLE(S)
22'

FIG. 19A

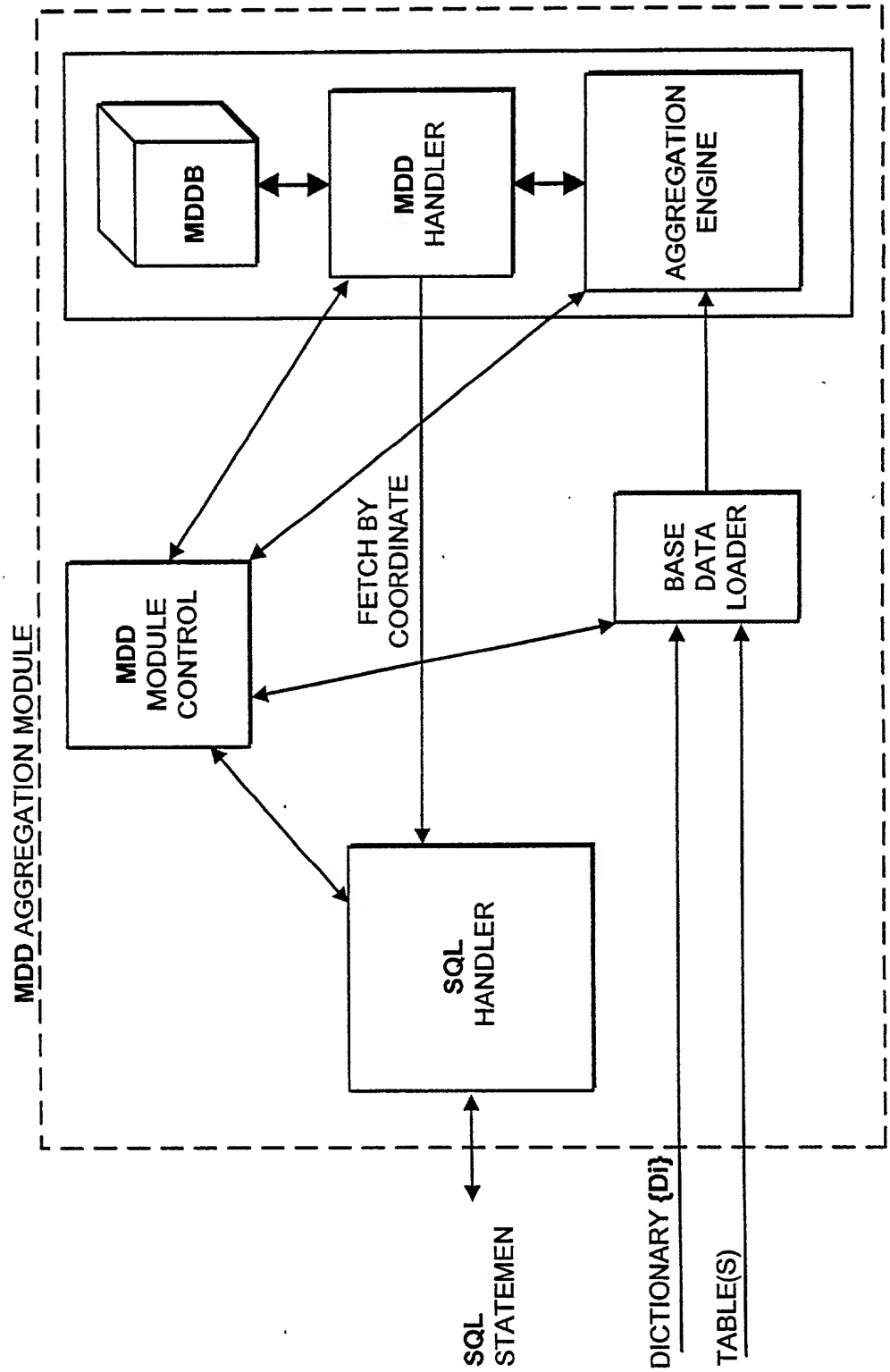
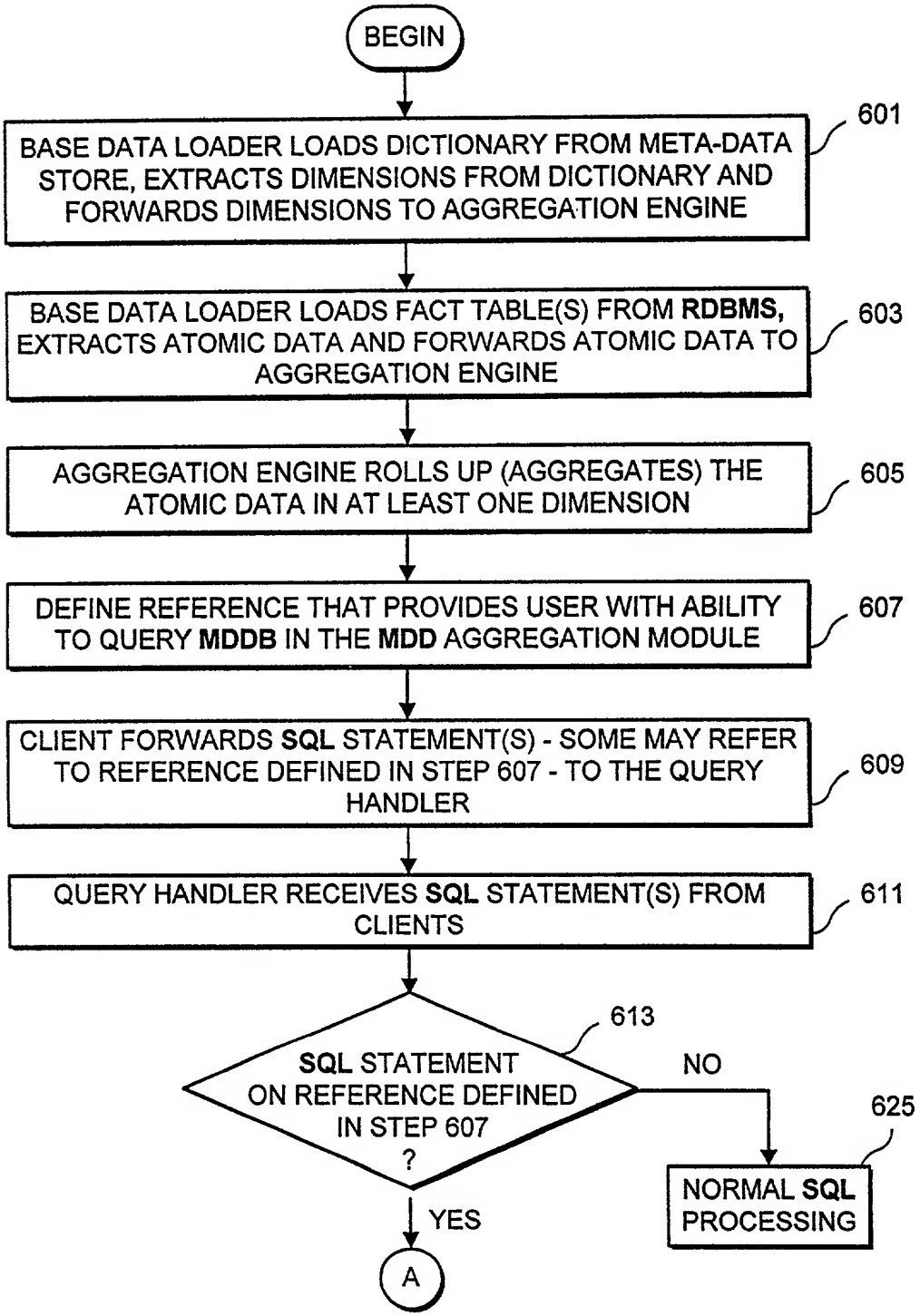
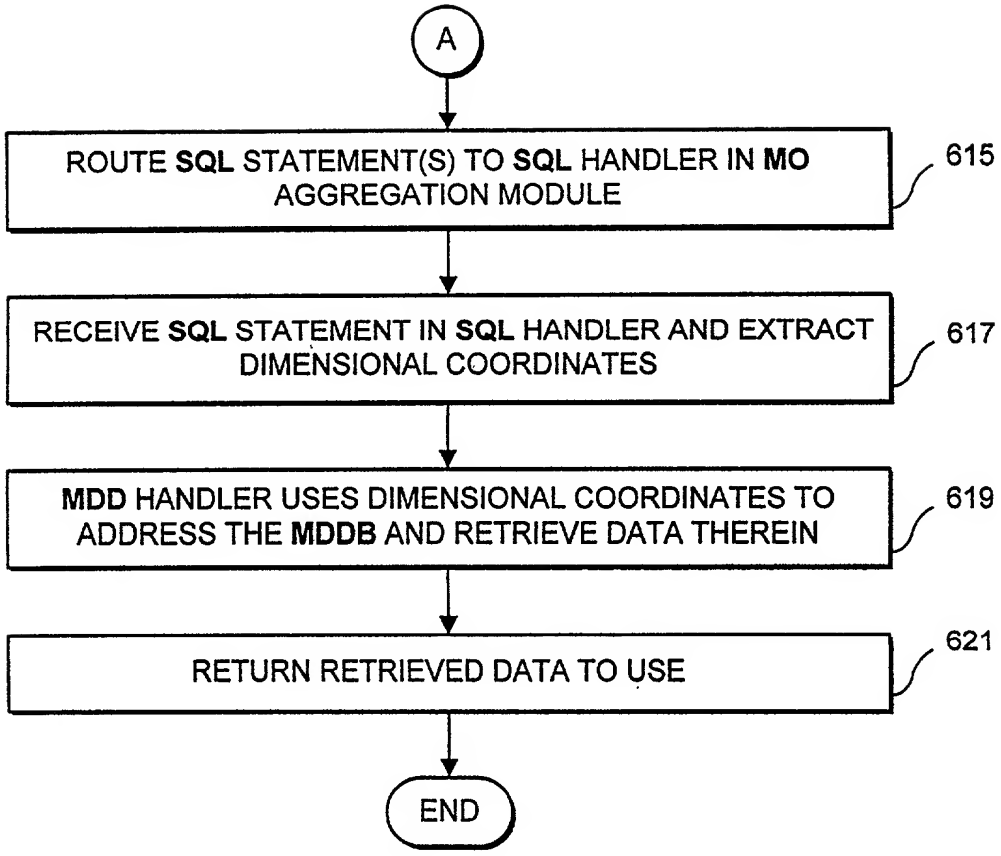

MDD AGGREGATION MODULE
MDDB
MDD HANDLER
AGGREGATION ENGINE
MDD MODULE CONTROL
FETCH BY COORDINATE
BASE DATA LOADER
SQL HANDLER
SQL STATEMEN
DICTIONARY {Di}
TABLE(S)

FIG. 19B


BEGIN
BASE DATA LOADER LOADS DICTIONARY FROM META-DATA STORE, EXTRACTS DIMENSIONS FROM DICTIONARY AND FORWARDS DIMENSIONS TO AGGREGATION ENGINE
601
BASE DATA LOADER LOADS FACT TABLE(S) FROM **RDBMS**, EXTRACTS ATOMIC DATA AND FORWARDS ATOMIC DATA TO AGGREGATION ENGINE
603
AGGREGATION ENGINE ROLLS UP (AGGREGATES) THE ATOMIC DATA IN AT LEAST ONE DIMENSION
605
DEFINE REFERENCE THAT PROVIDES USER WITH ABILITY TO QUERY **MDDB** IN THE **MDD** AGGREGATION MODULE
607
CLIENT FORWARDS **SQL** STATEMENT(S) - SOME MAY REFER TO REFERENCE DEFINED IN STEP 607 - TO THE QUERY HANDLER
609
QUERY HANDLER RECEIVES **SQL** STATEMENT(S) FROM CLIENTS
611
SQL STATEMENT ON REFERENCE DEFINED IN STEP 607 ?
613
NO
625
NORMAL **SQL** PROCESSING
YES
A

F I G. 19C(i)


A
ROUTE SQL STATEMENT(S) TO SQL HANDLER IN MO AGGREGATION MODULE
615
RECEIVE SQL STATEMENT IN SQL HANDLER AND EXTRACT DIMENSIONAL COORDINATES
617
MDD HANDLER USES DIMENSIONAL COORDINATES TO ADDRESS THE MDDB AND RETRIEVE DATA THEREIN
619
RETURN RETRIEVED DATA TO USE
621
END

F I G. 19C(ii)

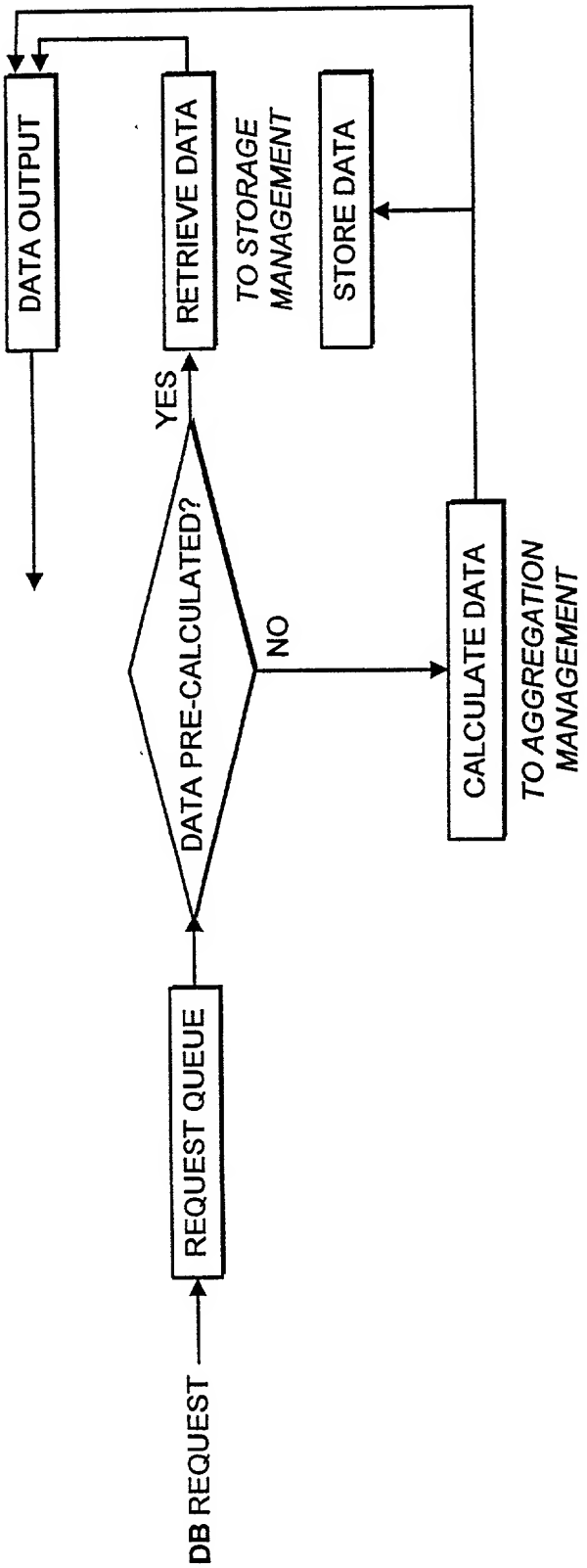

DB REQUEST
REQUEST QUEUE
DATA PRE-CALCULATED?
YES
NO
RETRIEVE DATA
TO STORAGE MANAGEMENT
STORE DATA
CALCULATE DATA
TO AGGREGATION MANAGEMENT
DATA OUTPUT

FIG. 19D

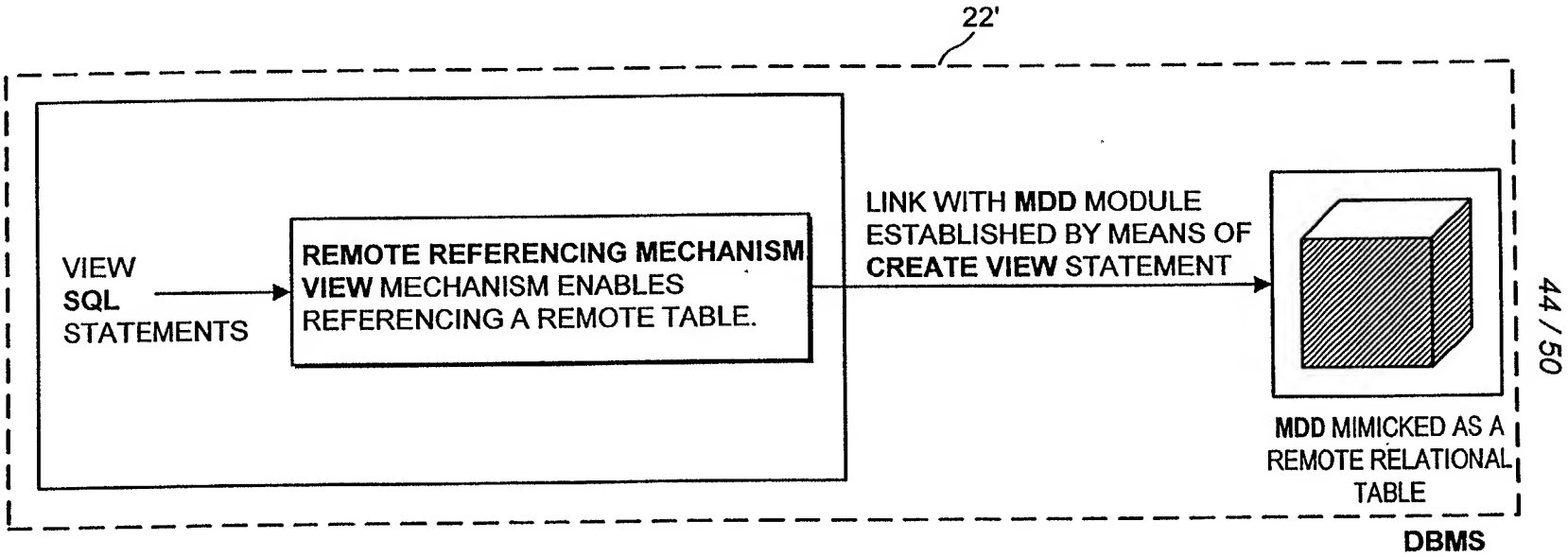

22'
VIEW
SQL
STATEMENTS
REMOTE REFERENCING MECHANISM
VIEW MECHANISM ENABLES
REFERENCING A REMOTE TABLE.
LINK WITH MDD MODULE
ESTABLISHED BY MEANS OF
CREATE VIEW STATEMENT
MDD MIMICKED AS A
REMOTE RELATIONAL
TABLE
DBMS

FIG. 19E

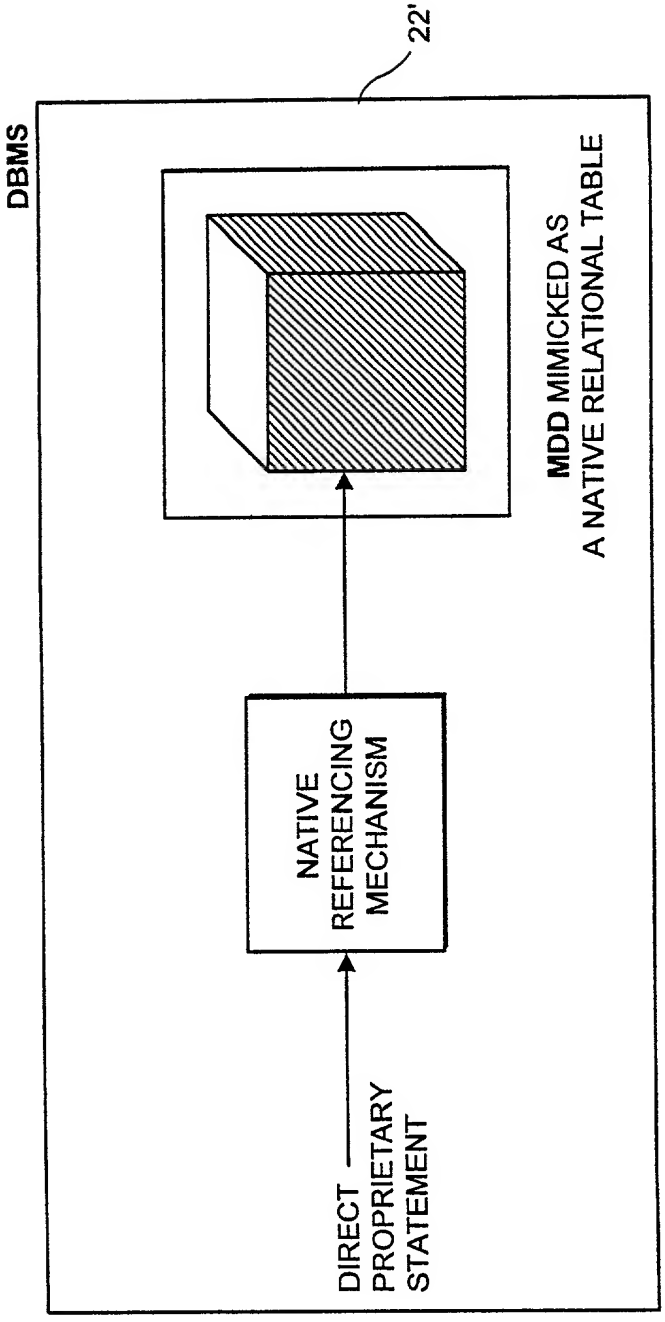

22'
DBMS
MDD MIMICKED AS
A NATIVE RELATIONAL TABLE
NATIVE
REFERENCING
MECHANISM
DIRECT
PROPRIETARY
STATEMENT

FIG. 19F

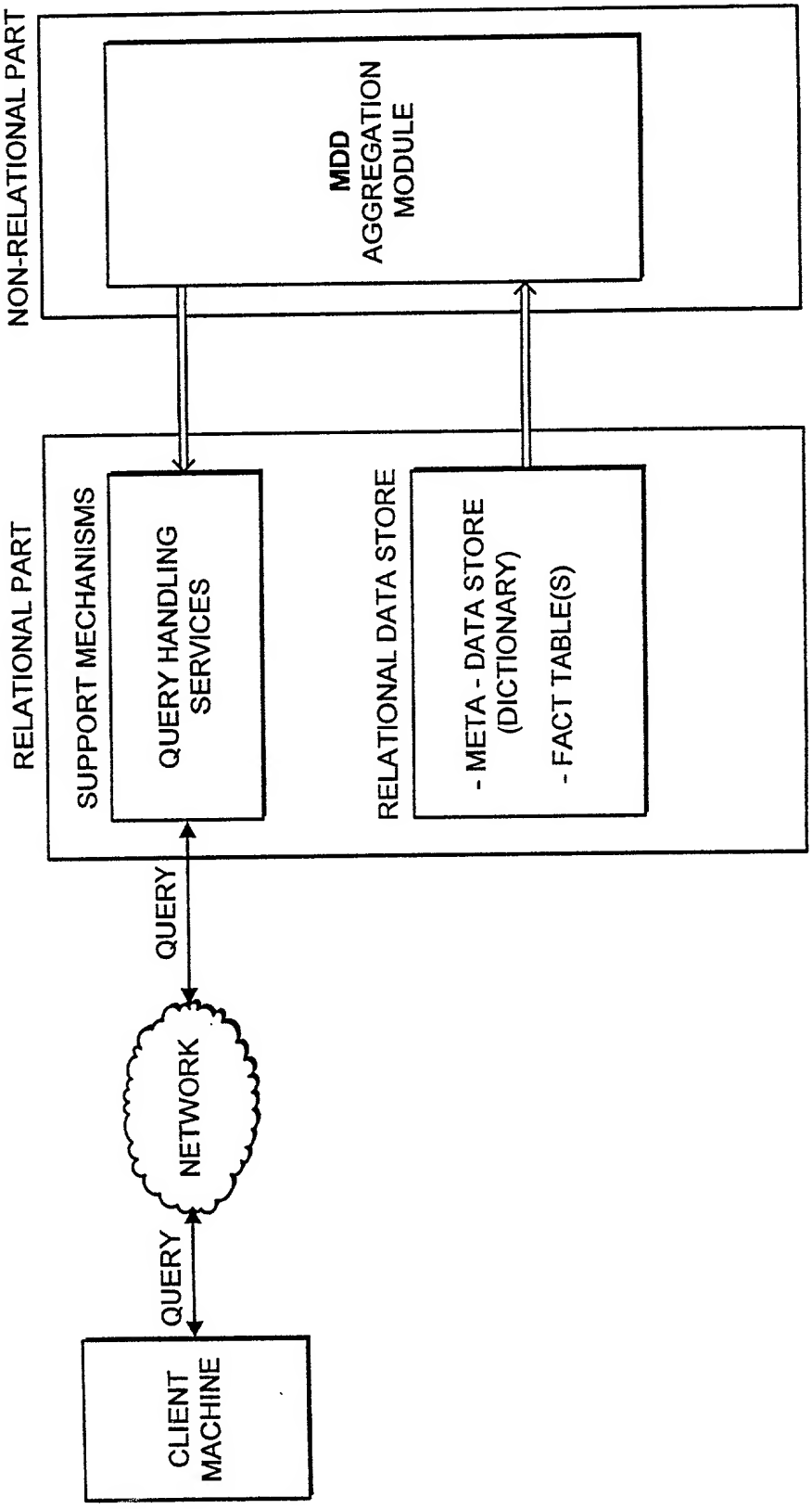

NON-RELATIONAL PART
MDD
AGGREGATION
MODULE
RELATIONAL PART
SUPPORT MECHANISMS
QUERY HANDLING
SERVICES
RELATIONAL DATA STORE
- META - DATA STORE
(DICTIONARY)
- FACT TABLE(S)
QUERY
NETWORK
QUERY
CLIENT
MACHINE

FIG. 19G

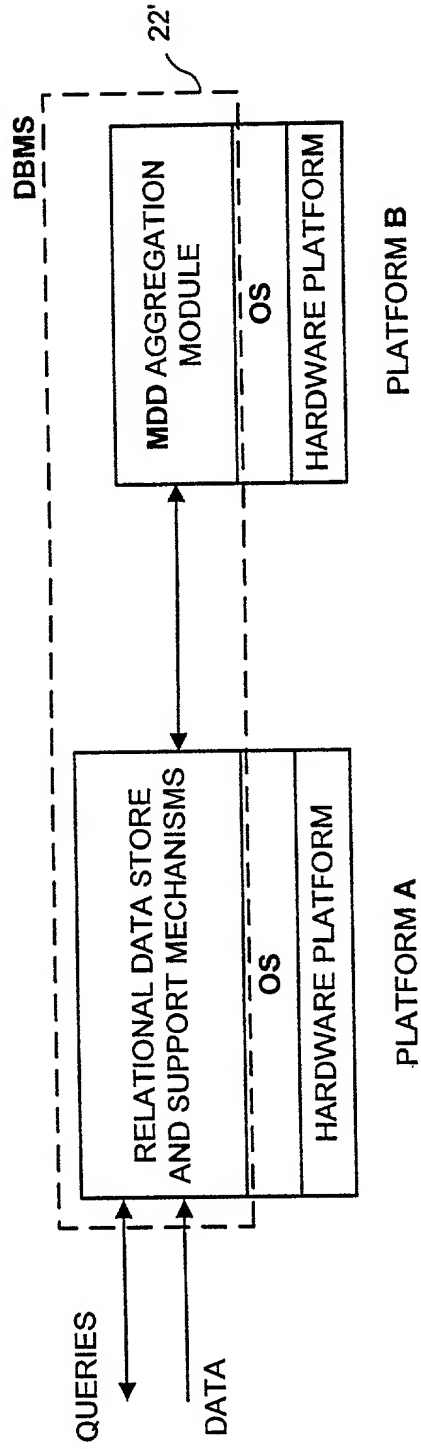

22'
DBMS
MDD AGGREGATION MODULE
OS
HARDWARE PLATFORM
PLATFORM B
RELATIONAL DATA STORE AND SUPPORT MECHANISMS
OS
HARDWARE PLATFORM
PLATFORM A
QUERIES
DATA

FIG. 20A

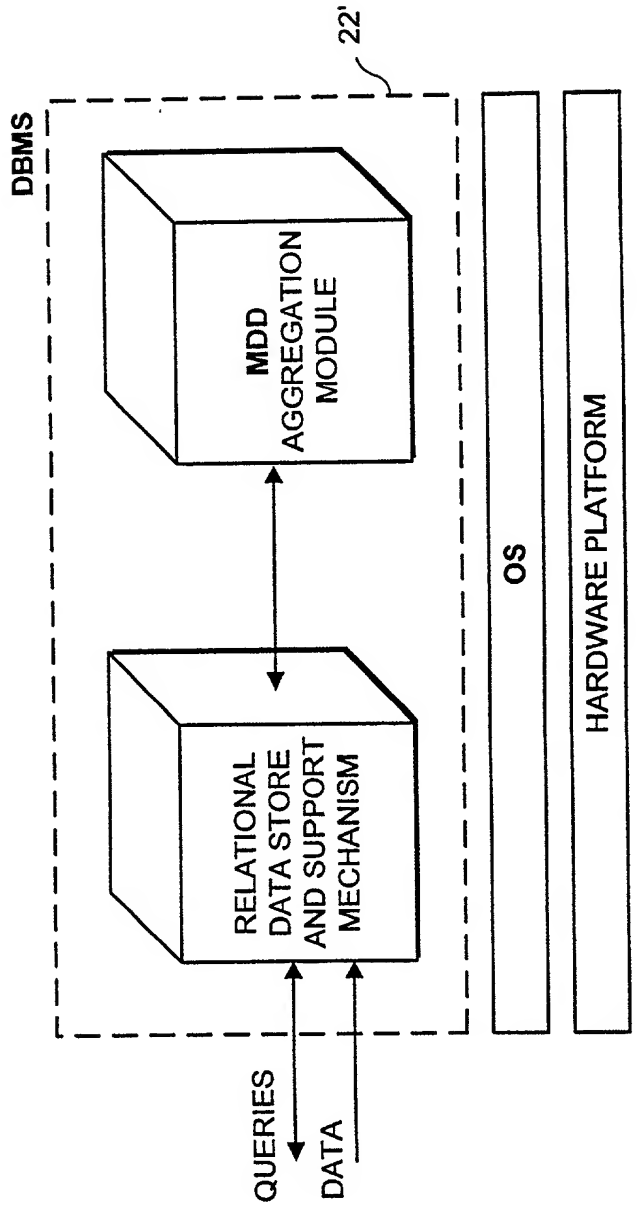

22'
DBMS
MDD AGGREGATION MODULE
RELATIONAL DATA STORE AND SUPPORT MECHANISM
OS
HARDWARE PLATFORM
QUERIES
DATA

FIG. 20B

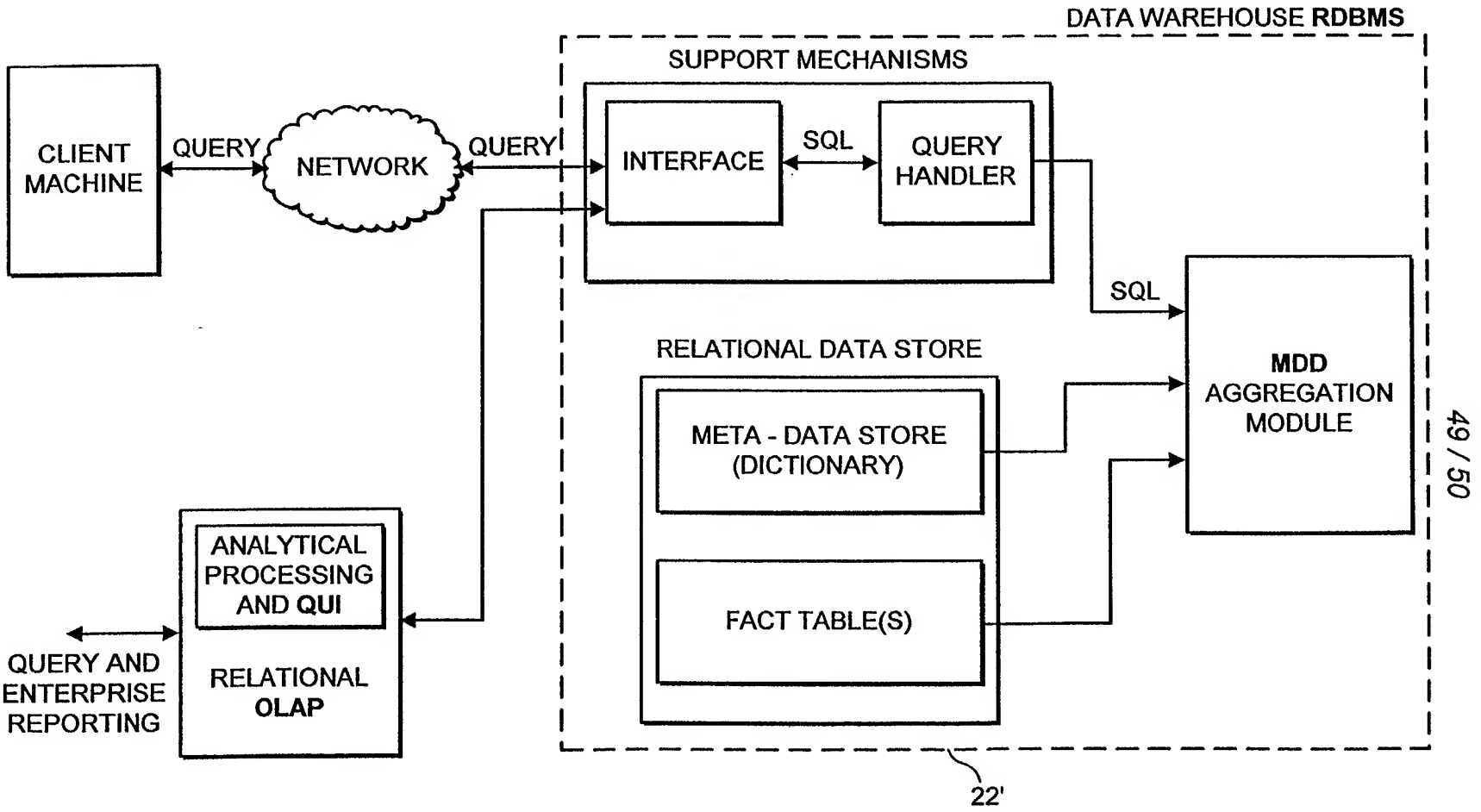
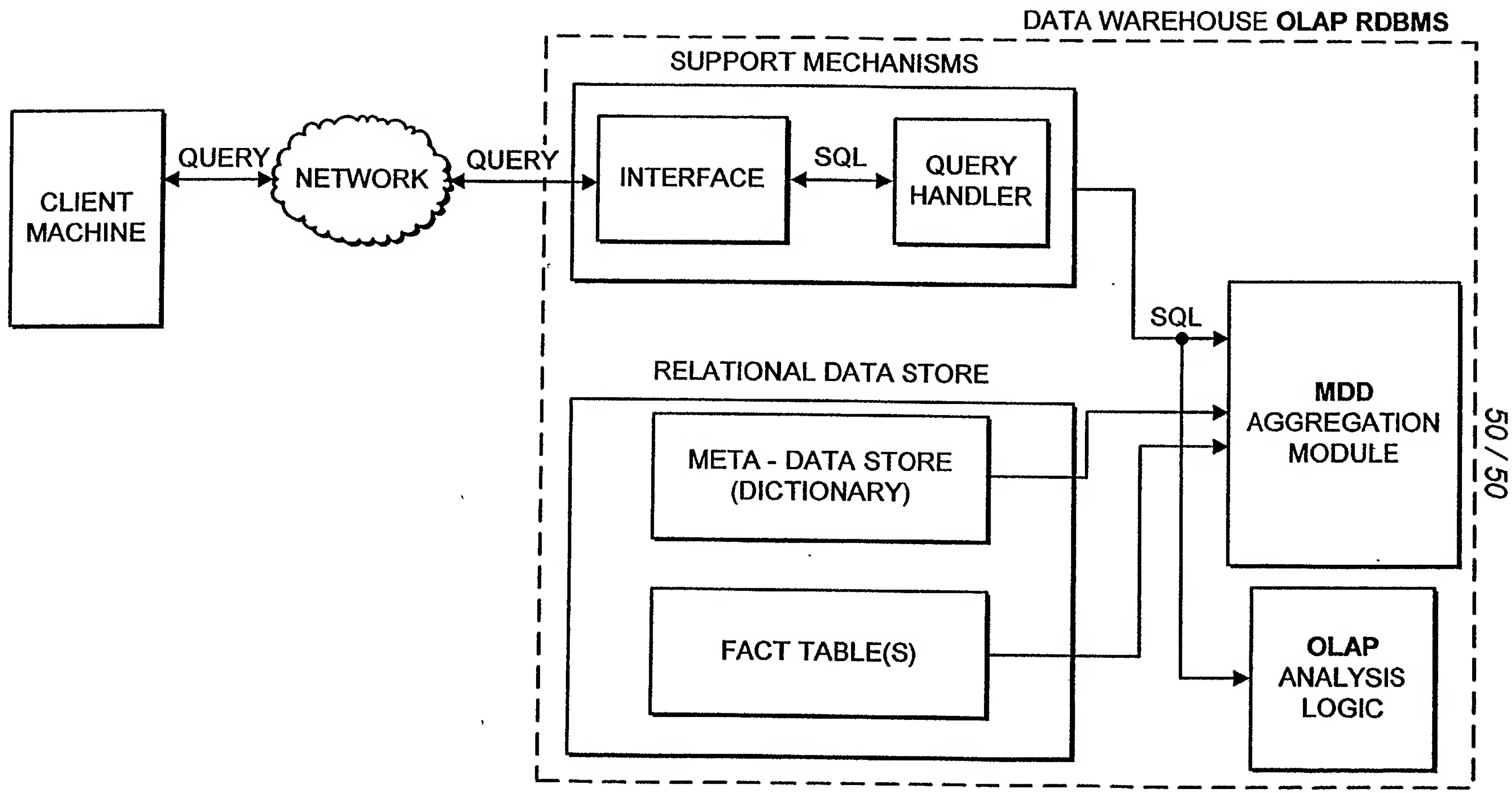

DATA WAREHOUSE RDBMS
SUPPORT MECHANISMS
CLIENT MACHINE
QUERY
NETWORK
QUERY
INTERFACE
SQL
QUERY HANDLER
SQL
MDD AGGREGATION MODULE
RELATIONAL DATA STORE
META - DATA STORE (DICTIONARY)
FACT TABLE(S)
ANALYTICAL PROCESSING AND QUI
RELATIONAL OLAP
QUERY AND ENTERPRISE REPORTING
22'

FIG. 21


DATA WAREHOUSE OLAP RDBMS
SUPPORT MECHANISMS
CLIENT MACHINE
QUERY
NETWORK
QUERY
INTERFACE
SQL
QUERY HANDLER
SQL
RELATIONAL DATA STORE
META - DATA STORE (DICTIONARY)
FACT TABLE(S)
MDD AGGREGATION MODULE
OLAP ANALYSIS LOGIC

F I G. 22